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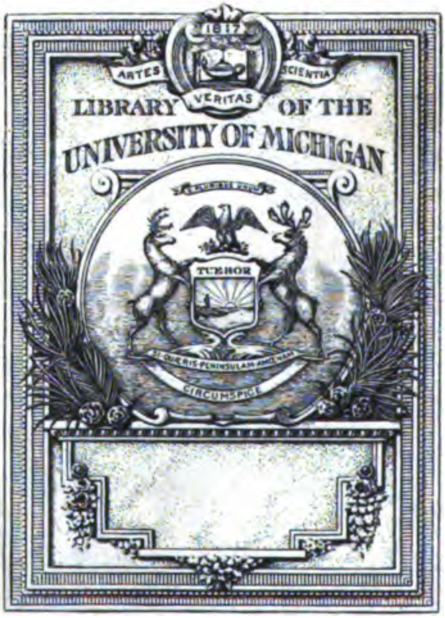
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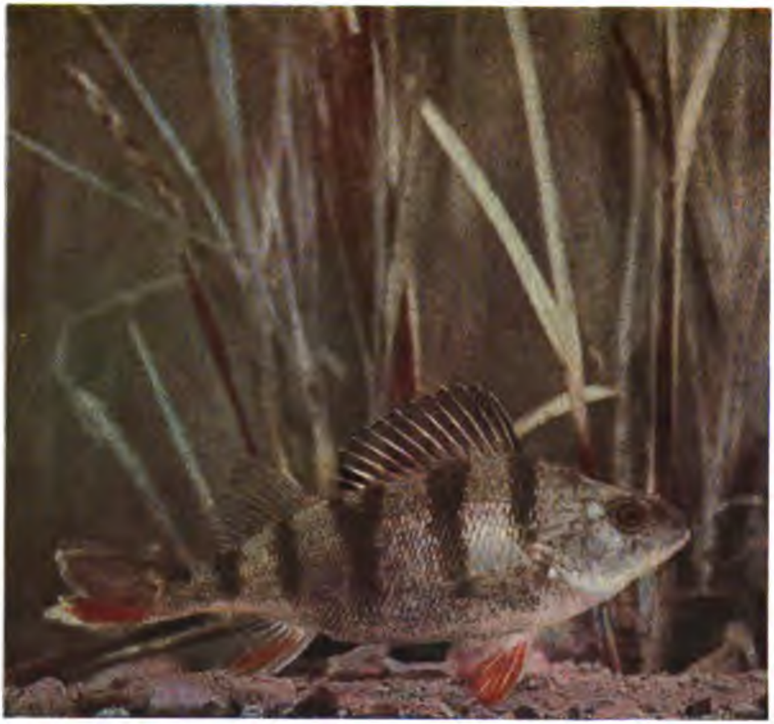

A PERCH PALING WITH FEAR.

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MARVELS OF FISH LIFE

As Revealed by the Camera

By **FRANCIS WARD**

M.D., F.Z.S., F.R.P.S.

Profusely Illustrated
with Photographs
from Nature

CASSELL AND COMPANY, LIMITED
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1911

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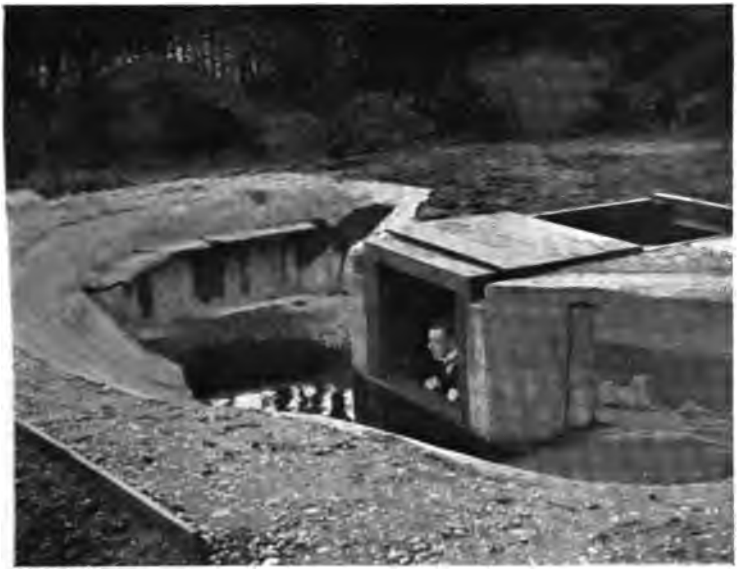

OBSERVATION POND EMPTY.

OBSERVER DESCENDING INTO OBSERVATION CHAMBER.

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INTRODUCTION

Year by year nature study becomes more and more popular, and countless books continue to appear describing the life histories of animals, birds and insects, but descriptions of fish life do not seem to have had their fair share of attention.

This is not because fish are less interesting than birds or mammals, but chiefly because of the difficulty of observing them in their native element.

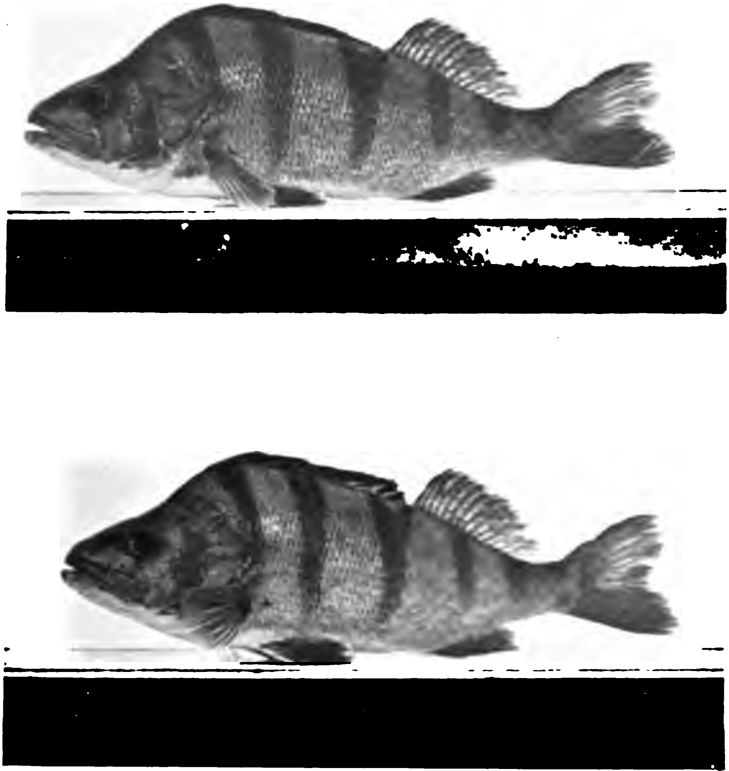
I have endeavoured in this book to show how fish reveal to the observer their intentions and emotions by attitudes, movements and changes in colour. I have described the eggs and the early life histories of a few of our commoner fishes, and how the adult fish is assisted in the battle for existence by concealing coloration and other devices. The habits of a few marine animals have been dealt with, and finally I have explained in detail how the various photographs shown have been obtained, in the hope that the information may be of assistance to those interested in fish photography.

If observations and illustrations of concealing methods are to be of any real interest, it is necessary that fish should be watched and photographed while swimming free in natural environments, and illuminated as in nature. For this purpose I have constructed a special pond, and fish turned into it in a few days are quite as much at home as in the waters they came from. A glance at the photograph of this pond, taken during the course of its construction, and before it was filled with water, will show quite clearly how it works.

The bottom and sides are of concrete. In one wall of the pond is a large open space, which communicates with an observation chamber, and between this chamber and the water in the pond is a sheet of plate glass. Concealed in the chamber, the observer can watch the fish as they appear to each other in the water. In consequence of the darkness in the chamber and the light in the pond, the glass is converted into a mirror, and the fish merely sees himself and his surroundings reflected, while the observer can plainly see into the pond. It is thus possible to observe a timid fish without disturbing him.

In addition, an instantaneous photograph can be taken of moving fish under three feet of water.

Photography of fish in the pond described is only one of the methods of obtaining illustrations, as shown in the present book. To show structure and colour arrangement, or when it is desired to make the fish conspicuous, the specimen is photographed in a large glass tank. These tanks have in them growing weeds, natural food, and running water, but the main



PERCH BECOMING PALE FROM FEAR.

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light is from in front instead of from above, as in the pond.

Some of the photographs of fish in their natural environments—for example, the young thornback ray facing page 44—are taken with the camera above the water. When taking a photograph of this kind, it is necessary to cut off the rays of light from the surface of the water, either by means of a shield held at a suitable angle, or by means of a tube in which is fixed the camera, the end of the tube being under the surface of the water.

The micro-photographs of fish life are taken with a special apparatus constructed for the purpose. All the illustrations, except those of colour cells, scales and teeth, are from living fish, and the photographs showing methods of concealment are from straight prints and untouched negatives.

It is possible some may read this book who have never previously taken any interest in fish. For their information I show a rainbow trout, with the chief external features numbered and marked.

I take this opportunity of thanking Professor Herdman for having enabled me to obtain photographs of the developing plaice, and Mr. Richmond, of the Surrey Trout Farm, Shottermill, for numerous fish and eggs supplied, and for interesting information with regard to the salmon family.

Among others who have assisted me in gathering material for this book, I would especially thank Dr.

Dakin, of Liverpool University; Mr. Chadwick, of Port Erin; the Misses Crisp, of Playford Hall, Suffolk; Mr. Crisp; Mr. Cook; and Mr. Hudson, of Ipswich; and numerous other friends who, from time to time, have supplied me with specimens of living fish; and, lastly, the Rev. H. A. Watts, for kindly revising the manuscript.

PIKE AS SEEN IN THE POND.
Photographed in Pond.

PIKE FOLLOWING UP A ROACH.
Photographed in Pond.

MARVELS OF FISH LIFE

CHAPTER I

ATTITUDES AND MOVEMENTS EXPRESSING INTENTIONS AND EMOTIONS

MOST people think of fish as dull, uninteresting creatures, leading monotonous lives. This is mainly due to the fact that they have only seen them in bowls, tanks, or in an aquarium, where natural food does not exist and where their enemies are conspicuous by their absence. That a fish's life is far from monotonous will be seen later, the object of the present chapter being to illustrate how interesting he is to watch when "At Home."

Many fish possess a certain degree of reasoning power, and often there is more truth in stories about the intelligence of fish than is usually supposed.

The pike is an exceptionally interesting fish, and well repays observation. Some years ago I kept a small pike for many months in my sitting-room. He became quite tame, and would nibble the end of a finger. By the side of his tank was a smaller one, which contained his food in the form of minnows; and resting on this smaller tank was a net for picking out the minnows.

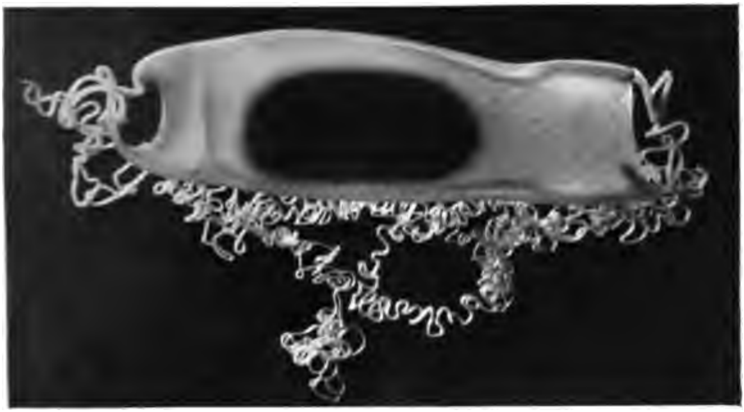
Time after time I have approached this pike without his showing any excitement, but as soon as I took up the net he would reveal his agitation, and a gleam would appear in his eye in anticipation of a meal.

The minnow, as soon as he was put into the tank, recognised a natural enemy, and the pike frequently had considerable difficulty in catching him. After one or two failures I have seen the pike retire into a corner of the tank, and, taking what shelter there was among the scant weeds, wait until the restless minnow, cruising round and round, had his tail towards him. Then, stealthily coming up from behind, he would rush forward and quickly seize his prey.

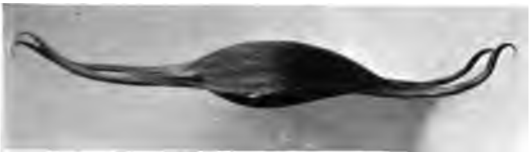
Rainbow trout turned into a pond soon learn to appreciate that an individual standing at a certain spot at certain times of the day means food, and will jump a foot or more out of the water to take it from the hand. At Port Erin Marine Biological Station there are two large ponds in which some four hundred plaice spawn, the eggs being gathered for the hatchery. During her stay of a month a lady made a pet of one particularly large plaice, and I have seen this fish come up to the edge of the pond when she approached, and put its head out of the water to be fed.

Next let us consider the attitudes and movements of fishes, and what they convey to us.

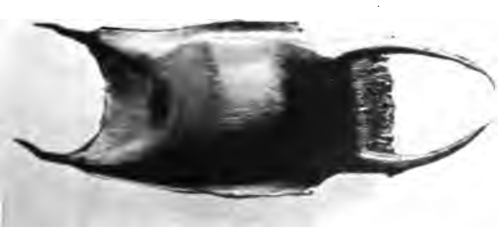
If we see a cat crouching behind a bush, motionless except for a spasmodic twitch of the end of his tail, we know the cat is watching a bird or a mouse, and he



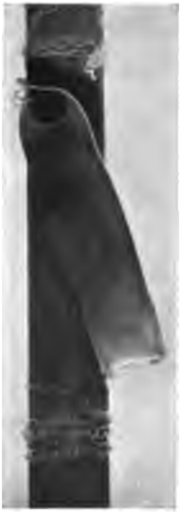
Egg of Dog-fish.



Egg of Ray. Side view.



Egg of Ray. Full view.



Freshly deposited Dog-fish Egg.

EGGS OF CARTILAGINOUS FISHES.

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reveals his suppressed excitement by the movements of his tail. If our fox-terrier, going out of the gate, suddenly drops on the ground with his head straight out in front of him, we can guess he is going to have a game with the mongrel next door, and he expresses his joy by wagging his tail. Had the dog suddenly pulled himself together and advanced on his toes with a stiff and stilted gait, the hair on his back erect and his tail quivering, it is fairly certain that in a few minutes he would have been engaged in a fight.

The attitudes and movements of the cat and the dog convey to us these meanings because we are constantly seeing them, and if, in the same way, we were constantly observing fish, we could read by the movements of their fins and bodies, and by their changes in colour, their intentions and emotions.

Watch the pike lying outside a reed-bed. He rests motionless on the bottom, with his body just off the ground, supported on his fins. The muscles of his body being relaxed, the line of the back shows a gentle curve, and the calm, contemplative state of his mind is revealed by the fact that the fin on his back is lying flat. That the pike is on the watch all the time is evident from the keen look in his eye. Suddenly, without any movement of the body or other fins, the fin on the back will become erect and fully extended, a sure sign of mental agitation. Probably the pike has detected a gleam of light in the distance as a dace turning on his side reveals his presence.

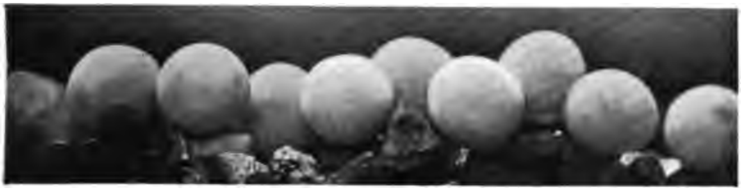
fish, except the salmon family, most shore fishes, and a few deep-sea fishes, deposit these heavy, adherent eggs. As illustrations, I have shown the eggs of the roach, attached to submerged roots, and those of the perch, the latter adhering to each other, and forming long, glistening ribbons, which are deposited on the roots and leaves of aquatic plants.

Lastly, we have eggs lighter than water. These are free, and float near the surface, and are found only in the sea. From this type of egg are hatched almost all our marine food fishes.

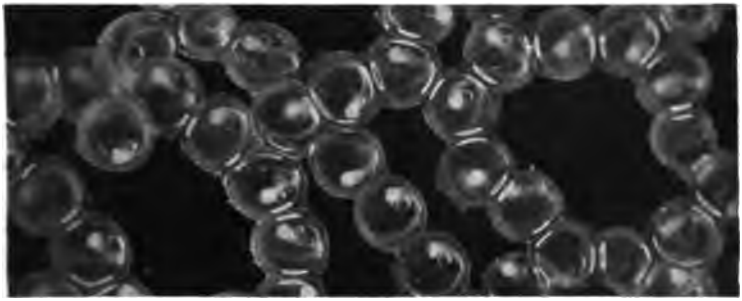
Floating eggs are very small, the largest being that of the plaice, which is about one-twelfth of an inch in diameter, and the smallest that of the dab, which is less than one-twenty-fifth of an inch in diameter. Others, for example, those of the sole, the cod, and the turbot, are of intermediate sizes.

Though, as stated, most of our food fishes hatch from floating eggs, herrings are an important exception. Herring eggs are heavier than water, and are found attached to stones and shingle at the bottom of the sea. In estuaries of rivers flowing into the Baltic the eggs of these fish have actually been found attached to freshwater plants.

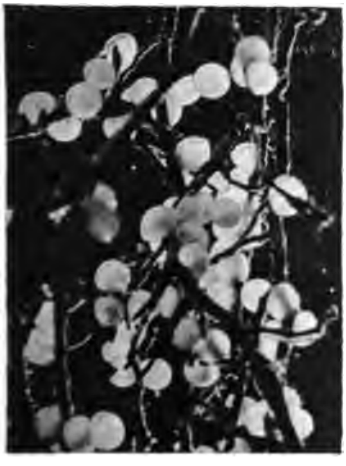
Floating eggs are perfectly transparent before the embryo develops, and even a number of plaice eggs in a tumbler of sea-water are difficult to detect. This transparency is for protective purposes, for when floating in the sea they are invisible to their natural enemies.



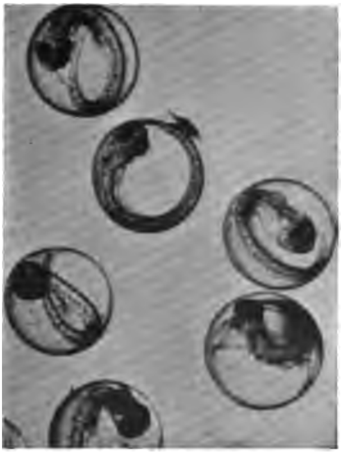
Heavy Eggs of Salmon, unattached to each other.



Heavy Eggs of Perch, attached to each other in ribbons.



Heavy Eggs of Roach, attached to roots.



Floating Eggs of Plaice.

EGGS OF BONY FISHES.

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The specific gravity of floating eggs is just below that of sea-water. Those shown in the illustration were touching one another when put in the photographic tank, but a copepod jumped on to an egg whilst I was focusing, and the weight of this minute crustacean, which is shown magnified eight times, scattered the eggs right and left.

All fish eggs can be classified under one or other of the types described.

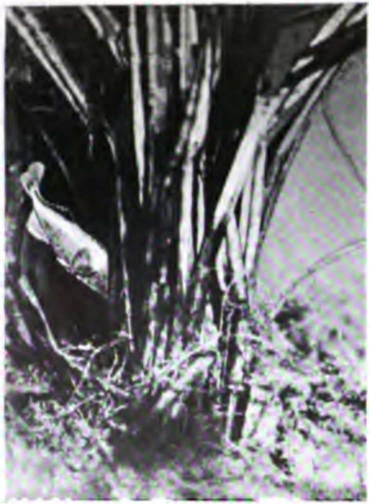
Among the majority of fishes parental responsibility ceases as soon as the eggs have been deposited, and the eggs are not guarded, nor are the offspring tended. Some fish, however, are extraordinarily zealous in their attentions to the eggs and young, but it is usually the male and not the female that exercises this care.

The males of several species build more or less complete nests, and the perfection of nest-building is reached by the ten-spined stickleback.

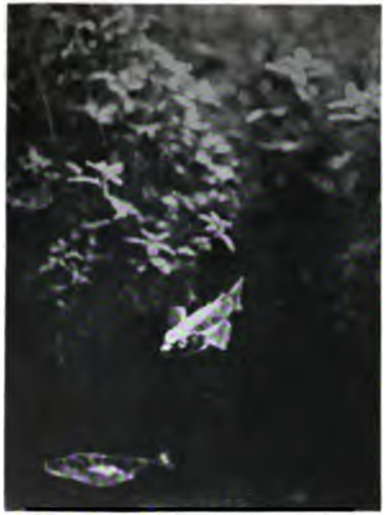
We get the other extreme in the nest of the sand goby, for this fish merely scoops out a hollow under the shell of the scallop as it lies on the bottom. The goby is a most attentive father, although he does not build an elaborate nest, for by a continual movement of his pectoral fins he drives a current of oxygen-laden water over the eggs as they lie under the scallop-shell, and in this manner prevents them from being suffocated.

To realise how seriously the male fish takes his parental duties, one has but to watch the breeding of the three-spined stickleback. During most of the year the male and female fish are coloured alike, being olive-green and grey on a silvery background, but about April the male fish, in order to attract the opposite sex, becomes brilliant in colour. At first there is a mere reddish tinge on the under-surface, but as the time approaches for him to build his nest his sides and under-surface, and even the inside of his mouth, become scarlet, his back turns a greenish blue, and his little eyes become a brilliant emerald. When he decides to build he first scoops out a hollow in the ground, and then arranges round this hollow small pieces of roots, weed-stems, and other debris, either tugged from the growing vegetation or picked up from the bottom. Wriggling through this untidy mass, he binds the pieces together with the mucus from his body.

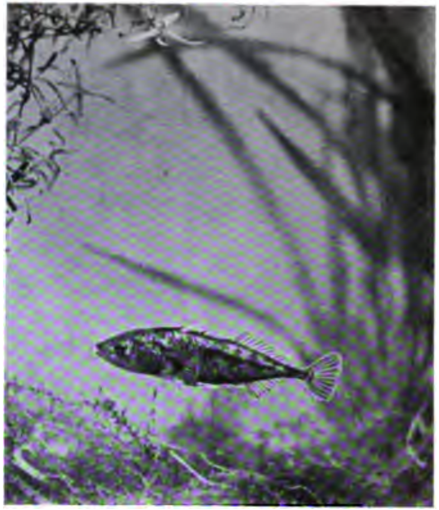
Next he nips off bits of the same roots and stems, and, after chewing them well in his mouth, rams them into the bottom of the nest. Having put in three or four mouthfuls of material in this manner, he will suddenly dart off into the adjacent weeds, talk for a few seconds to his intended bride, and then return brighter in colour to tackle his work with renewed energy. These periodic visits stimulate the secretion with which he welds together the building material. Finally the end and roof of the nest are completed, and it appears as a mound on the ground, surrounded by general debris. Working from early dawn to dark without intermission, the stickleback completes his task in a couple of days.



MALE STICKLEBACK BUILDING NEST.



MALE STICKLEBACK DRIVING FEMALE TO NEST.



STICKLEBACK ON GUARD.

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Next, he seeks the lady of his choice with the purpose of inducing her to lay her eggs in his nest. First, he tries to persuade her, swimming round and round and advancing before her, but should his blandishments fail, he suddenly becomes annoyed, and erecting the spines on his back he endeavours to drive her to the nest with several well-directed nips from his powerful jaws.

If, during these endeavours to persuade the lady to visit his nest, a second male appears upon the scene, a battle royal ensues. Brilliant in colour and bristling with rage, the jealous fish bite and chase each other through the weeds. At the conclusion of the fight the vanquished combatant, immediately losing his brilliance, slinks off to his own quarters, while the victor, becoming, if possible, still more brilliant in colour, advances to the female stickleback, who has been demurely watching the fray, and without much difficulty persuades her to visit his nest, and deposit her quota of big eggs.

The nest, when completed, is a tube closed at one end. But whereas the male used to back out when leaving it, the female, after laying her eggs, bores her way through the closed end of the nest, thus converting it into a tunnel. This is a useful provision, for later the male fish aerates the eggs by sending a stream of water through this tunnel with a fanning movement of his pectoral fins.

When the female fish has laid her eggs, the fickle male drives her away, and, going through the same manœuvres, induces five or six others to add their eggs to those already in the nest, until the required complement of some eighty eggs is made up.

The male then mounts guard, a very necessary procedure, for should he wander far from home, the very females who laid the eggs, and the other sticklebacks in the water, would pounce down upon the nest, tear it to pieces and devour the contents.

When on guard the stickleback's spines are flat on his back. Should an enemy approach too near, up go the spines as an intimation to trespassers that he is ready to defend his home, if necessary, with his life.

When the young sticklebacks hatch, the father's cares are redoubled; for very soon they escape from the nest, and would be devoured were it not for the fact that the parent fish darts after them, seizes them in his mouth, and literally spits them back into their nursery.

Constant attention, periodic fights, and the impossibility of wandering far in search of food, play havoc with the stickleback's constitution. He becomes thinner and thinner, and when his brood are ready to leave the nest and fend for themselves, not infrequently the exemplary father dies.

When nesting, the male fish becomes excessively bold, and if disturbed with a stick, he will viciously bite the end.

Another example of parental care is found in the male pipe fish. This long narrow fish carries the eggs and, afterwards, the young pipe fish in a pouch, in a similar manner to the kangaroo. Even after the young

STICKLEBACK ON GUARD.

STICKLEBACK RESENTING INTRUSION OF THE CAMERA.

STICKLEBACKS DEVOURING EGGS.

have commenced to swim about, they return to the parental pouch when alarmed. And strangest of all is the arius, a fish found in Ceylon and Guiana, which protects its eggs by carrying them in its mouth.

There appear to be only one or two cases in which the female alone takes charge of the eggs. One is a fish (*Aspredo batrachus*) about a foot in length found in tropical Africa. The skin on the lower part of this fish's flattened body becomes soft and spongy, and when the eggs are laid she presses them into the spongy skin by lying on the top of them, and carries them about with her in this way until the young are hatched. As soon as this has occurred, the skin on the under-surface of her body becomes as smooth as before.

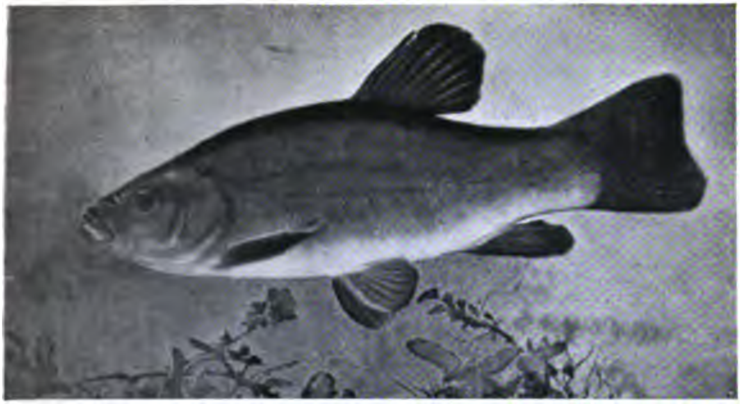
A parallel to this we find amongst amphibians in the toad known as the pipa, except that in the toad it is the skin of the back that becomes spongy. Both the male and female butter fish take their share in guarding their eggs by rolling the eggs up into a ball, and each in turn wrapping his or her long body round the mass.

The number of eggs deposited by any particular fish is directly in proportion to the protection they receive and to the likelihood of their being fertilised. The ling merely sheds her eggs into the sea, and produces over half a million eggs to each pound weight of her body.

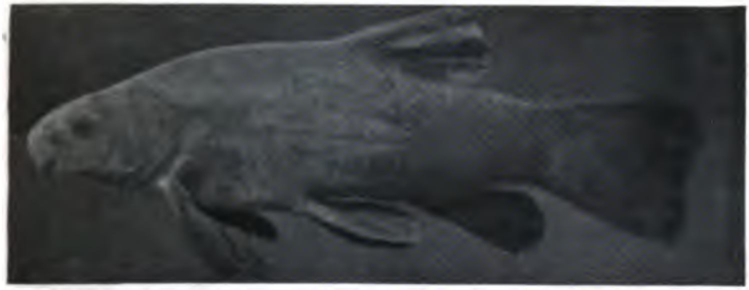
The trout deposits about a thousand eggs to each pound weight of her body, for these are partially protected by being buried in the gravel. The stickleback, although found in every pond, stream and puddle, gathers but a mere seventy or eighty eggs into the protection of his nest, and of the eggs with horny cases, only one, or, at the most, two, are deposited at a time.

It stands to reason that when any particular species of fish deposits an enormous quantity of eggs, an enormous number must also be destroyed, or that particular species would soon swamp all other fishes. When investigating the life history of the roach, I made the following count of roach eggs, which may assist in enabling us to appreciate the amount of destruction that occurs amongst unprotected eggs.

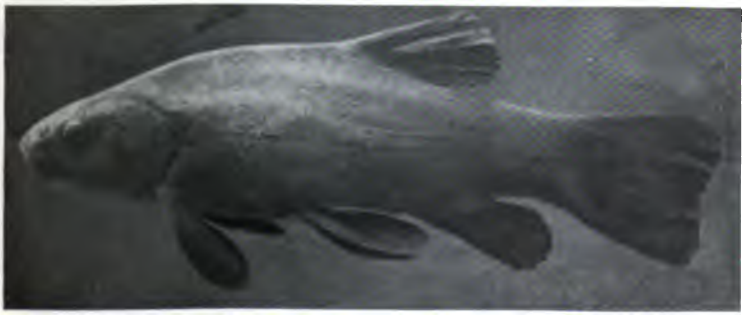
Along one side of a pond grew a row of poplar trees, and on the submerged roots of these trees the roach used to lay their eggs. Measuring out fifty yards along the bank, with the assistance of two friends, I gathered all the eggs in certain measured areas, and estimated that in the fifty yards there were seven million five hundred thousand eggs. During the next four days a pair of ducks busily ate up all the eggs just below the surface of the water, shoals of young roach cruising round and round, picked them off during the day, and both night and day big and little eels literally sucked the roots clean. On the fourth day we again counted the eggs in similar areas, and estimated that in the place of seven millions a mere ten thousand were left. The fish did not appear to trouble further about these few scattered eggs, but when one considers that a similar destruction occurs among young roach, from their larval stages, it will be



TENCH, AS ACTUALLY COLOURED.



TENCH, AS SEEN UNDER THREE FEET OF WATER IN THE POND.



TENCH, AS SEEN UNDER SIX INCHES OF WATER IN THE POND.

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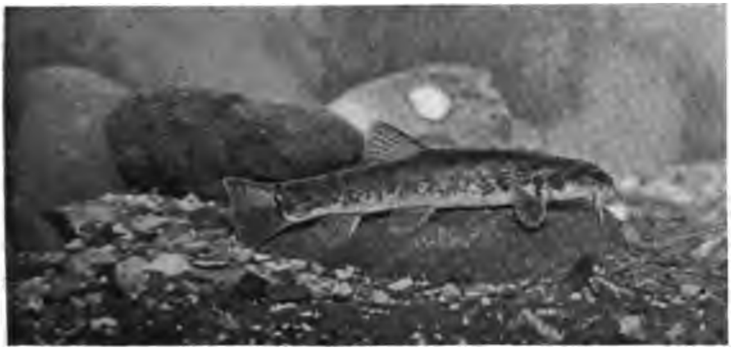
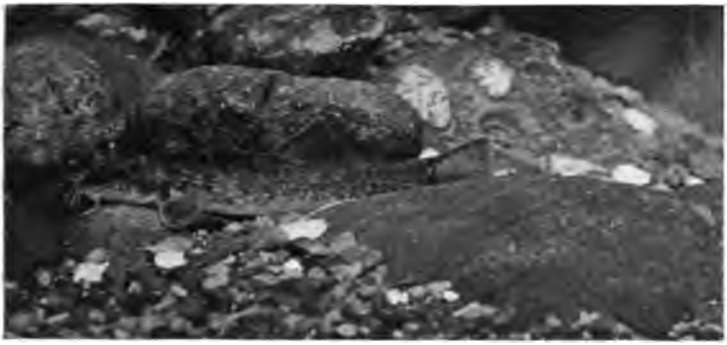
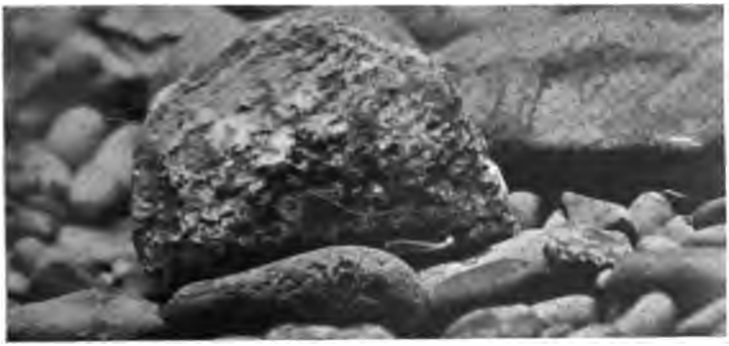


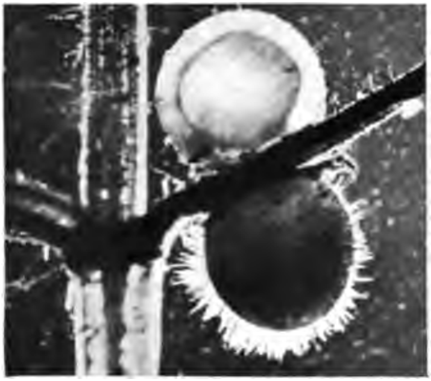
STONE LOACH, SHOWING ACTUAL ARRANGEMENT OF COLOUR AND MARKINGS.



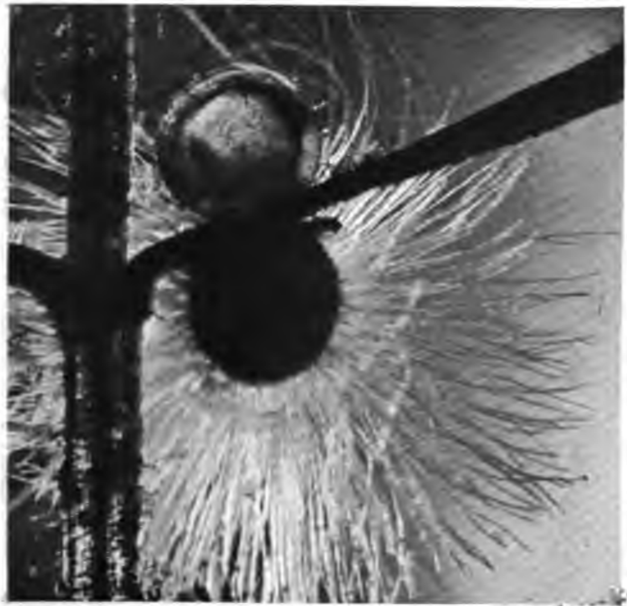
STONE LOACH, SHOWING HOW MARKINGS ALONE DO NOT CONCEAL.



STONE LOACH, SHOWING HOW MARKINGS SEEN ON A UNIFORMLY COLOURED FISH DO CONCEAL.



Dead Egg of Minnow, with first appearance of Byssus.



The same Egg nine hours later.

FUNGOID GROWTH ON DEAD EGG.

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realised how infinitesimal a percentage of eggs result in adult mature roach. The same enormous destruction of eggs is the rule rather than the exception throughout the fish world.

If an egg is unfertilised it soon dies, becoming white and opaque. A like fate is shared by fertilised eggs when under observation, if great care is not taken to keep them under conditions similar to nature, as to light, temperature and oxygenation. On the dead eggs of freshwater fish very soon appears a fungoid growth, commonly known as byssus.

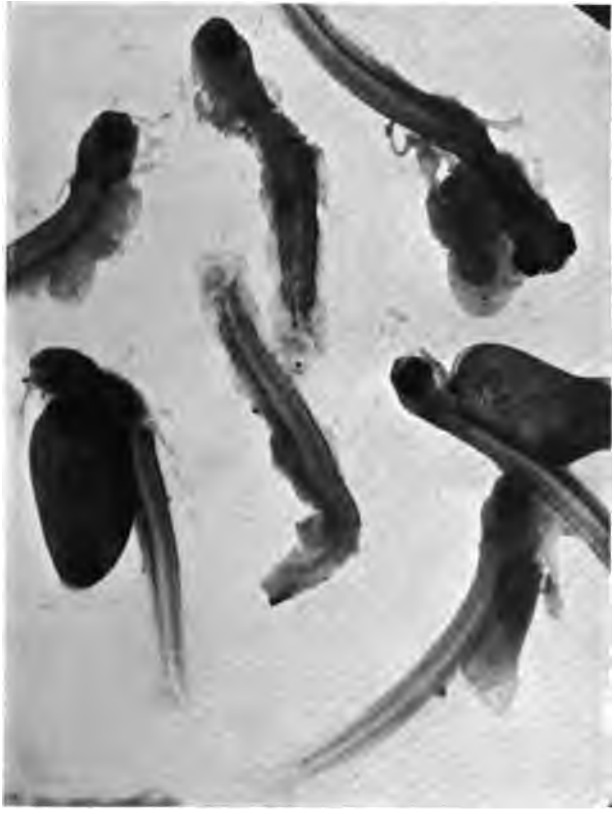
The appearance to the naked eye of an egg attacked by byssus is that of a minute white woolly ball. Under the microscope short shreds are seen growing out all round the dead egg. The growth of byssus is very rapid. In the illustration of byssus the second photograph was taken only nine hours after the first. This exceptionally rapid growth was due to the powerful light used, which warmed up the water in the photographic cell.

Byssus only attacks eggs and fish when dead, but what is commonly known as fungus (*Saprolegnia ferax*) attacks eggs and fish during life.

An illustration is given showing the utter devastation that fungus will cause among the young trout when they are attacked by it.

Many of us who have kept gold and other fish, in tanks or in small ponds in the garden, have occasionally noticed white patches appear on the fins and body, and have seen the fish sicken and gradually die off. These white patches are patches of *Saprolegnia ferax*. Fungus attacks fish when they are weak and unhealthy, and the cause of the trouble is usually to be found in want of cleanliness, in insufficiently oxygenated water, and in want of shade for the fish. To treat fish when attacked, if the trouble has not gone too far, is not difficult. Dissolve two or three handfuls of common salt in a bucket of water, and let the diseased fish swim about in this until they turn on their backs. Revive them in fresh water, and repeat the process two or three times, and for the future keep them in healthy surroundings.

Big patches of fungus may be treated by swabbing with a strong solution of Condy's fluid, and a lump of rock salt occasionally placed in the tank or aquarium is a deterrent to fungus. Above all, the woodwork must be charred or painted, otherwise fungus is sure to appear.



TROUT ALEVINS DESTROYED BY FUNGUS
(Saprolegnia ferax).

CHAPTER III

SEEN WITH THE EYE OF A FISH

IT has been stated that the sea is but a butcher's shop, and that a fish lives but to eat or be eaten. The codling, for instance, when feeding among rocks, may at any moment be encircled in the deadly clasp of a cuttlefish. When searching for food in more open water, he may fall a prey to the smaller members of the shark tribe. Again, if he comes near the surface, he may be immediately swooped down upon by a cormorant. Among animals he has to avoid the porpoise, the otter and the seal, and lastly his home is continually being raked backwards and forwards, night and day, by the nets of men.

Though surrounded by all these dangers the fish's life is nevertheless a happy one, for he does not suffer from nerves, neither does he appreciate the significance of capture. If the fish realised that capture meant death, on those occasions upon which he escaped from an attack, you would expect him to hide away and remain in hiding for a considerable time. Such, however, is not the case, for he merely shoots aside with a whisk of his tail, and is soon feeding again within a few yards of the place where his enemy passed.

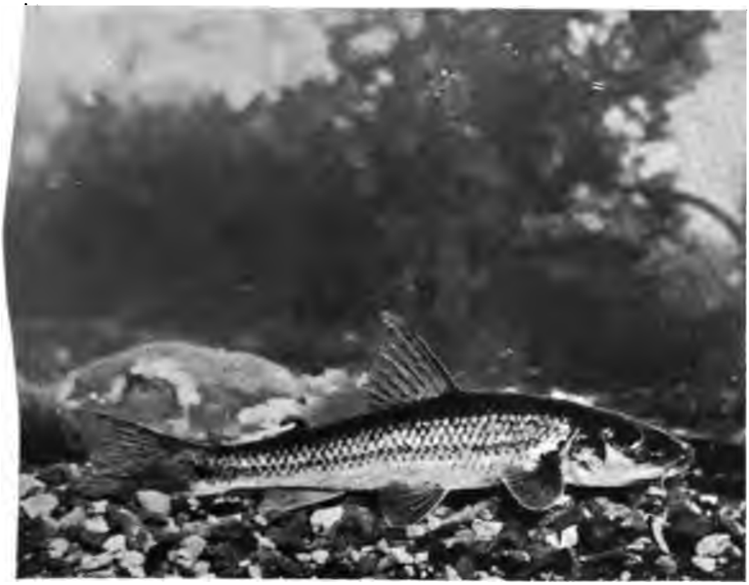
Nature has shaped and painted the cuttlefish, the shark and the seal so that they are not easily detected by the little fish, and his chances of surviving would be small were it not that he in his turn is shaded and coloured so as to afford him protection from these enemies.

In order to describe the various concealing devices found in the fish world, I propose to take six fishes, differently shaped, coloured and marked, and to deal with each in turn; first, describing how they appear to us when seen out of the water, or in a tank or bowl, and then how they appear to other fish when seen in their natural surroundings.

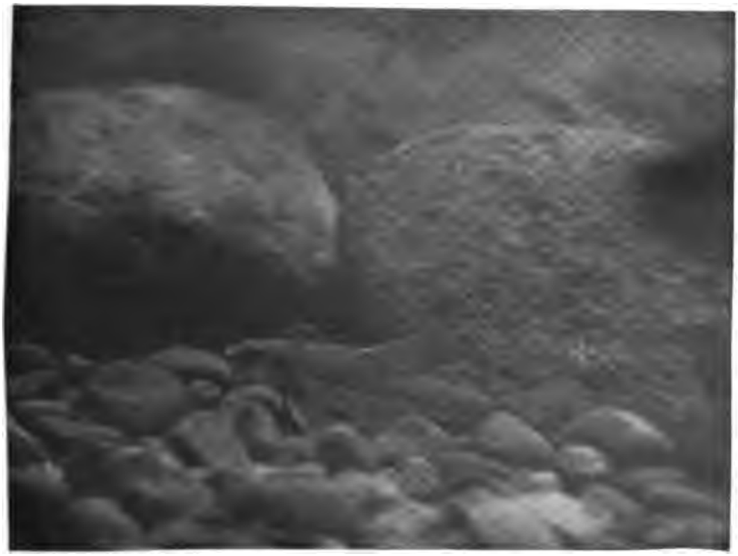
Let us start with the dace as an example of silvery-bodied fishes. When seen out of the water the back is dark, the under-surface white, and the sides a silvery colour. When seen in the water fish of this type become inconspicuous because of the fact that their bodies are perfect reflectors.

A dace at the bottom of a dark, deep hole appears almost black, but should this fish swim straight up, his body would exactly reflect the shade and colours of the strata of water he passed through, until at the top he would be seen as a light greenish-blue shimmering form under the surface of the rippling water. If seen amongst dead sedges the dace is yellow, if amongst green weeds he appears to be green, and if the weeds are sufficiently near to his body each stem and leaf is reflected.

As an illustration of how the dace reflects any par-



GUDGEON AS PHOTOGRAPHED IN A TANK.



GUDGEON AS SEEN IN NATURAL ENVIRONMENTS.

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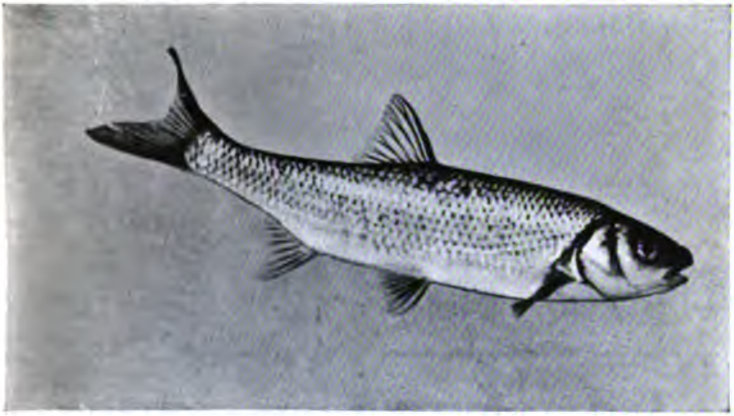
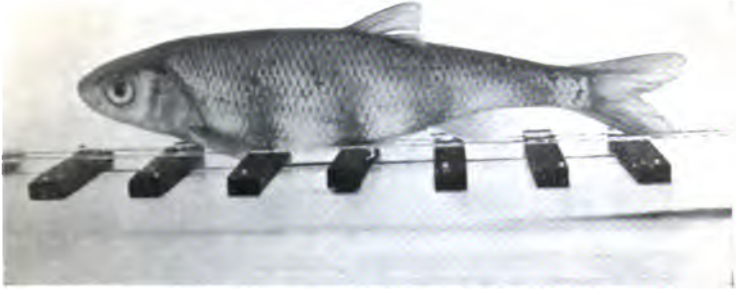


DACE, SHOWING ITS DARK BACK, SILVERY SIDE AND WHITE UNDER-SURFACE.

As depicted in books.



DACE REFLECTING BARS UPON ITS BODY.

ticular object on his body, I nailed a row of miniature sleepers from a toy electric railway, on a piece of tin, and, placing the tin under the water, I fixed two sheets of glass, one inch apart, so that they were supported on the sleepers. A dace introduced between the sheets of glass soon rested on the bottom, and reflected each single sleeper on its body, as shown in the photograph.

To demonstrate how the dace reflects the tone and colour of his surroundings, I constructed a wooden tank, with one side of glass. The first illustration of this tank shows a dace in the centre, lighted from above and from in front. The photograph of the dace taken by this illumination shows it as a silvery sided fish against a dark background, for the light reaching the side of the fish through the plate glass and eighteen inches of clear water is reflected back; the other side of the fish was dark, reflecting the dark back of the tank.

Next, I nailed a rug on the rail above the glass, and carried it over the camera. The glass side of the tank was now as dark as the wooden side, and the dace seen from under the rug appeared by reflection dark against the dark background. From the two illustrations of the dace, photographed in the wooden tank, it will be seen that the dark fish, illuminated only from above, as in nature, is much less conspicuous than the silvery fish.

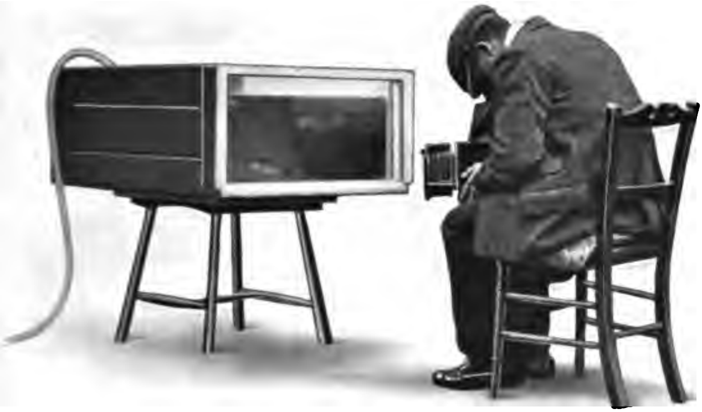
Do fish conceal themselves by reflection in a similar manner in their native element? A glance at the photograph of the two dace swimming free in the observation pond shows how, by reflecting the shade of the water around them, their ghost-like forms are almost lost in the expanse beyond. The cloud effect in the water is due to shimmering lights, which reached to the bottom of the pond, for while this photograph was being taken the sun was shining and a breeze was rippling the surface of the water.

To show how completely a silver-bodied fish reflects colour, put a dace, roach or rudd in a basin, and hold near it strips of coloured paper. Not only will the body of the fish show these colours, but they will appear even more brilliant on it than on the strips of paper when under the water.

Silvery fish are only inconspicuous so long as they swim on an absolutely level keel. If they turn ever so little on their sides, light from above is reflected, and a gleam is seen in the dark water. Watch the live bait of a pike angler; though the captive may be three or four feet below the surface, you will see flashes of light as the fish twists and turns in his endeavours to get free.

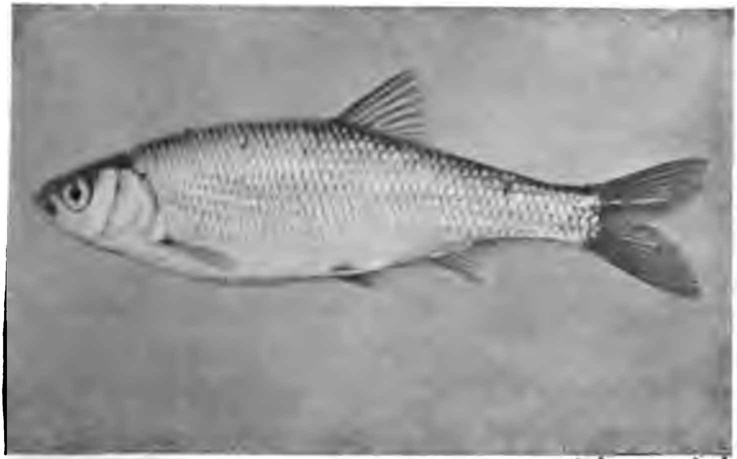
I have heard anglers say that the pike is attracted by the bait because the pike sees it is in trouble, but I am sure the real explanation is to be found in these gleams of light which arouse the greed of the pike. The more lively the bait, the more the flashes of light, the more likelihood of a run from a pike; but a dull captive bait seldom excites attack, for, leisurely swimming round on a level keel, he is as inconspicuous as the free fish around him.

Again, in these gleams of light, I think we have an



PHOTOGRAPHING A DACE, LIGHTED BOTH FROM ABOVE AND FROM IN FRONT.

This is how we usually see fish in tanks and aquaria.



DACE.

Result of photograph taken as in the above illustration.

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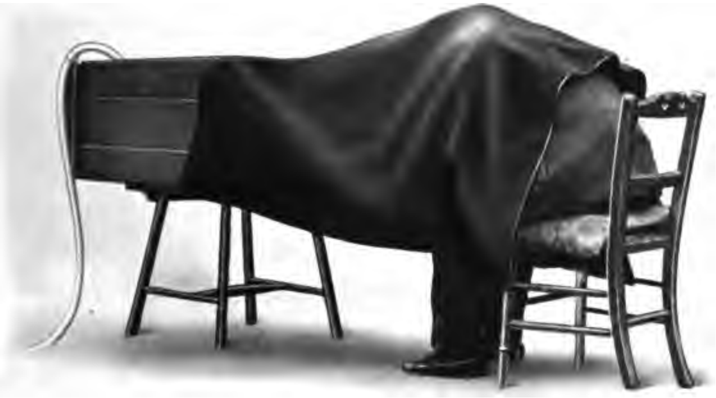
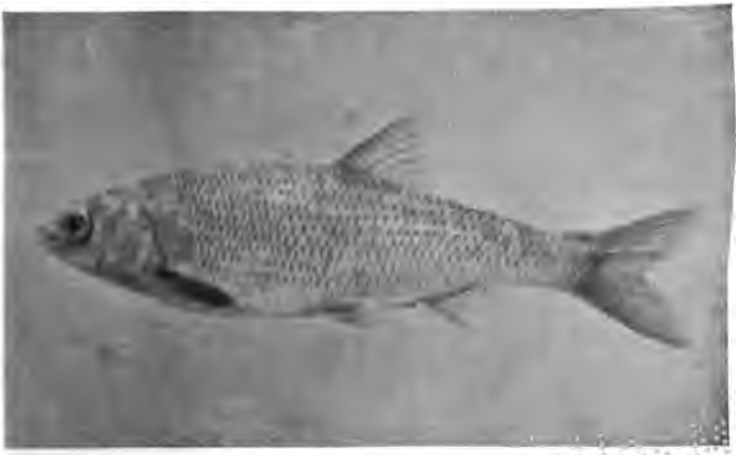


PHOTOGRAPHING A DACE, LIGHTED ENTIRELY FROM ABOVE.



DACE REFLECTING ITS DARK SURROUNDINGS.

Result of photograph taken as shown in the above illustration.

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explanation why we so seldom see a dead dace, roach or rudd in our ponds and rivers. The balance of a fish is maintained by the action of the pectoral and pelvic fins, and of these there is one on each side. If a healthy fish inclines, say, to the right side, automatically with a down stroke of the pectoral and pelvic fins on that side he restores his balance; but a weakly or dying fish loses this perfect balancing power, and slowly turns on one side; then as he realises he is going over he makes an effort and rights himself. These movements result in long gleams of light flashed through the water at regular intervals, and the attention of the pike, perch or trout is soon attracted, and he has no difficulty in catching his weakly prey.

When one realises how very slightly a fish has to turn on his side to reveal himself, it is remarkable that we so seldom see a silvery glint as he dashes through the water.

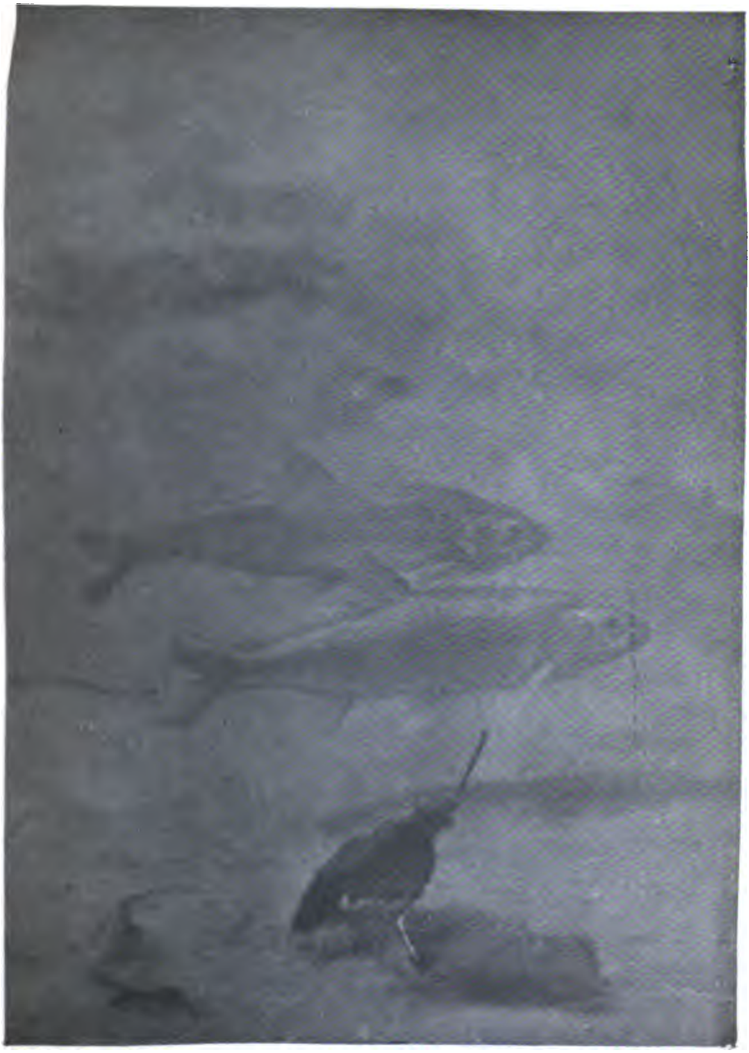
Watch trout shooting off a shallow into a pool above. It is possible you may detect the shadowy form, but more often than not the only indication of the position of the fish is the point of the wedge-like ripple as he leaves the gravelly bed. When fish swim rapidly they do so by swishing their tails from side to side, and there certainly would be sufficient roll of the body for the silvery sides to catch the light from above, were it not for the fact that a fish when he swims fully extends his dorsal and anal fins, and these, acting like the keel of a boat, keep him in a straight course.

Looking for an explanation as to how the body of the dace forms so perfect a mirror, we find it in the fact that in the deep layers of the skin are numerous mother-o'-pearl-like spicules. These, except on the back, are welded together to form a continuous reflecting surface. On the sides of the fish, in addition to this deep reflecting surface, spicules are also present outside the scales, and these acting like so many prisms, catch and break up the light reflected from below, and thus give the sides of the dace their silvery appearance.

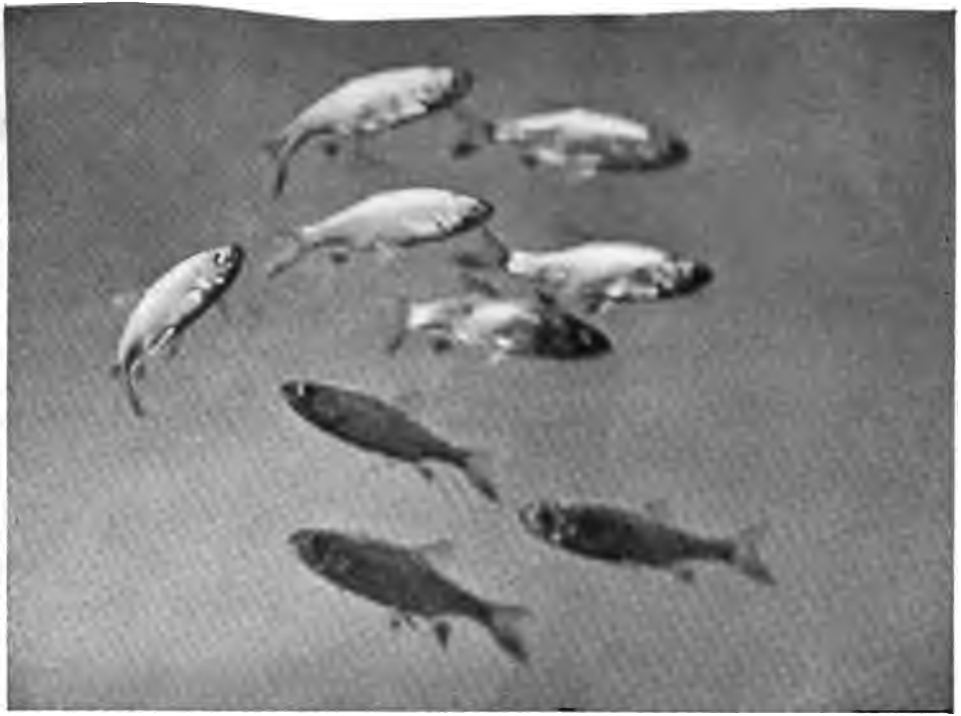
The glorious iridescence and changing colours, seen to perfection in the mackerel, are due to these prism-like spicules being present above the colour cells in the skin. Glitter and iridescence is another concealing scheme of nature, found amongst surface-swimming fishes, for light falling on waves and broken water cause a dancing shimmering glare below the surface, and a silvery iridescent fish in these surroundings is difficult to detect.

We have considered the reflecting power of the dace. What of the dark back, and how does this assist in concealing the fish?

If the dace reflected equally well all round his body, the sides and under-surface would reflect the dark water, but the back reflecting the light from above would show a silvery gleam, and at once make the fish conspicuous; so in the skin of the back we find numerous dark-colour cells, with light reflecting spicules scattered among them. These colour-cells, by contracting and relaxing, regulate



DACE SWIMMING FREE IN THE POND.
This is how fish appear to other fish in the water.



SHOAL OF YOUNG RUDD SEEN AGAINST THE SURFACE OF THE WATER FROM THE BOTTOM OF THE POND.

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the amount of light reflected by the back, and so the whole fish is of a uniform shade, be that shade light or dark.

The foregoing remarks on concealment refer only to fish when seen from somewhere about the same level in the water. When a fish is observed from above, his dark back makes him difficult to detect against the dark bottom, and, as will be seen later, should the bottom against which he is seen vary, the shade of his back will also vary to suit his surroundings.

The only position in which a fish is conspicuous is when seen from below, for then he appears silhouetted against the light of the sky.

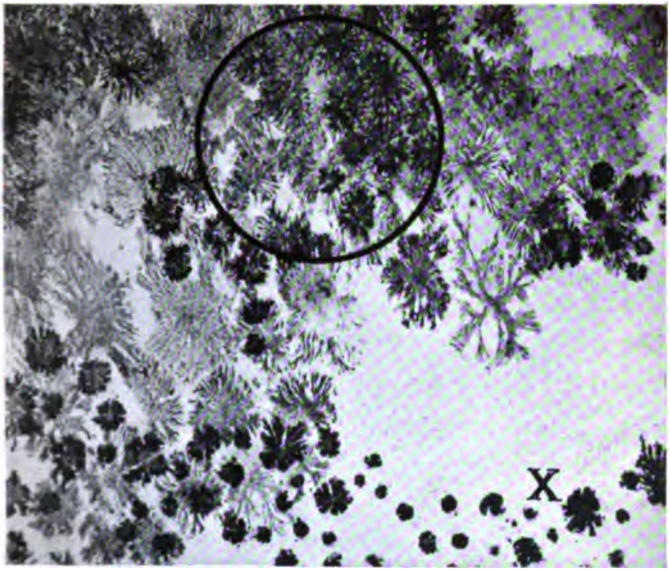
I show a photograph of a shoal of young rudd seen from below and outlined against the surface of the water. This is how they would appear to a pike patiently waiting on the bottom and watching for his prey. The rudd are seen to be wheeling round to the right. The three lowest fish, which have already commenced the wheeling movement by slightly turning on their left sides, reflect the dark water below them, and are seen as silhouettes against the sky. The right sides of the fish above them are catching the light, and appear to be living bars of silver. It will be noticed that the leading rudd on the top line is again coming on to a level keel, and in consequence reflects less light.

When walking along the river bank, or standing by the side of a pond, where small fish abound, many of us have, no doubt, seen a certain spot in the water which appears to sparkle with glittering light. Next moment nothing is visible, and in a minute or two similar flashes of light are to be observed in quite a different part of the water. These flashes are caused by the young fish simultaneously wheeling round with the precision of a crack regiment.

The fact that objects seen from below appear as silhouettes against the sky, explains why many fish on the look-out for food lie near the bottom. The spinning bait, or the fly, fished just under the surface, will bring up the salmon, the trout or the pike from the bottom of the deepest hole.

I well remember watching from the bridge above the fishing of a pool on the Dee. A sunk fly was fished past and in front of a salmon lying on a ledge of rock without response, but when fished right above him he twice came up to inspect it. I do not suggest that the salmon could not see the deep fished fly, but that when fished right above him it was much more obvious against the sky, and so attracted his attention. I would mention in passing that the most gaudy fly seen against the surface of the water merely appears as a grey, iridescent silhouette, and for this reason I do not think the colour of the fly matters if the size be right for the condition of the water and the fly be fished so as to suggest life.

Having so fully considered both concealing coloration and reflection in the silvery dace, let us turn our attention to fish in which colour plays the greater part



ORANGE, BLACK AND YELLOW PIGMENT CELLS IN SKIN OF LOACH.

The colour-cells within the ring are relaxed, and the skin is hard.

PIKE WITH TAIL IN THE LIGHT.

PIKE WITH HEAD IN THE LIGHT.

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in making them inconspicuous, though even with these fish reflection is an important factor.

To appreciate how wonderfully the colour and markings on a fish conceal him, we must briefly consider the colour cells themselves, how by their contraction and relaxation a fish becomes light or dark, and how by an alteration in the arrangement of these cells, fresh patterns are made on the fish's body to hide him in altered surroundings.

Looking at the photograph of the skin of the stone loach, we see black, orange and yellow pigment cells are present. These cells have branching processes, and are capable of rapid contraction and relaxation. The skin and flesh of our bony fishes are colourless, and also scattered between the pigment cells are light reflecting spicules. Now look at the cells within the ring on the illustration; all are relaxed, and the space within the ring appears dark. Should the cells in this ring contract into little dots like those at point x, the colourless skin would show through between the pigment cells, and the space within the ring would become pale.

We naturally ask ourselves what it is that makes the pigment cells contract and relax? Light is the stimulus that causes the cells to contract; in darkness they again relax. Light, however, does not act directly on the colour cells, but through the medium of the fish's eye. To demonstrate this I divided a tank into two chambers by means of a piece of linoleum, in which a hole was cut large enough for a small pike to pass through. One chamber was painted white, the other was covered up and quite dark. The pike was first placed with his head in the dark chamber, and with his body and tail in the light chamber. Here he remained for two hours, water running through the tank all the time. At the end of the two hours a photograph was taken, and you will see that in consequence of the eye of the pike being in the dark chamber the pigment cells remained relaxed, and the body of the fish was, therefore, dark.

The pike was then turned round so that the head was now in the light. In three minutes a second photograph was taken. The entire fish at once became pale, as shown in the illustration, in consequence of the contraction of the dark pigment cells caused by the stimulus of light acting through the eye.

Fear and emotion cause a similar contraction of the dark pigment cells, thus a fish becomes pale when alarmed. This point has already been illustrated in the first chapter when considering the emotions of fishes.

Next let us consider the tench. The colouring on this fish may be taken as an example of that found in fishes inhabiting dark open waters, such as the sea and deep ponds. The sides are a golden olive-green, the back is very dark, and the under-surface white. When seen as in nature, the tench, like the dace, becomes of a uniform shade, the under-parts darkening and the back becoming lighter, so that the whole is brought to the same shade as the sides of the fish.

It is not realised, however, to what extent a fish like the tench reflects the light; and to illustrate this I placed a tench in an all-glass tank, and, sinking the tank into the pond, I photographed him under three feet of water. The result was a uniformly-shaded dark fish. I then raised the tank and tench to within six inches of the surface, and the black back of the fish now appeared almost white.

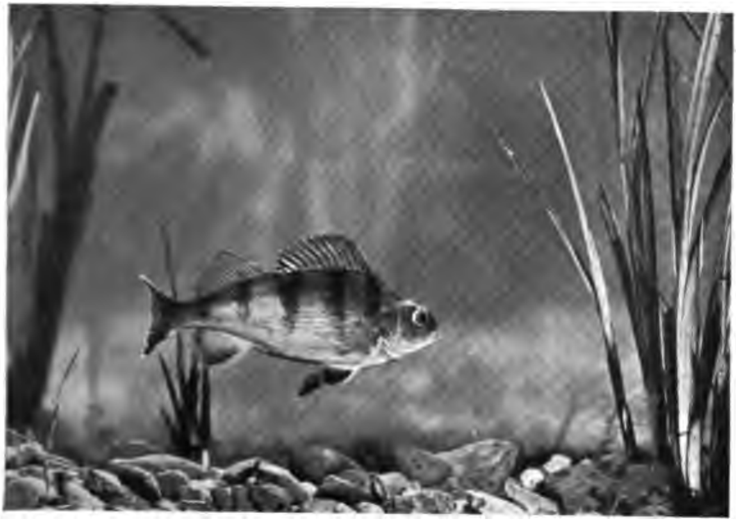
Fish that appear of a uniform shade in the water are only protected against a uniform background. Many fish live among rocks, stones, reeds, weeds and other vegetation, and these, in addition to having dark backs and light under-parts, have special markings to assist in their concealment.

Markings are mainly of two types: spotty or blotchy markings, to make them inconspicuous amongst rocks and stones, and striped markings, to conceal them amongst vegetation. As an example of fish with stone-like markings, let us consider the loach. I show three illustrations of this fish photographed by different lights. In the top illustration the loach is shown perched upon a stone, illuminated by a front light. It was only after considerable difficulty that the fish was persuaded to remain in this unnatural position while I photographed him in order to show the dark back, the white under-surface, and, on the top of this colour arrangement, the special stone markings. He was then allowed to swim off and hide himself, as shown in the middle illustration. But even in this position he was not concealed, for the photograph was again taken by a front light, and he is still revealed by his dark back and white under-surface. The stone-like markings in themselves were insufficient to conceal him. In the bottom illustration the fish was photographed by a top light only, and now we see how effectively the markings seen on a uniformly shaded fish conceal him.

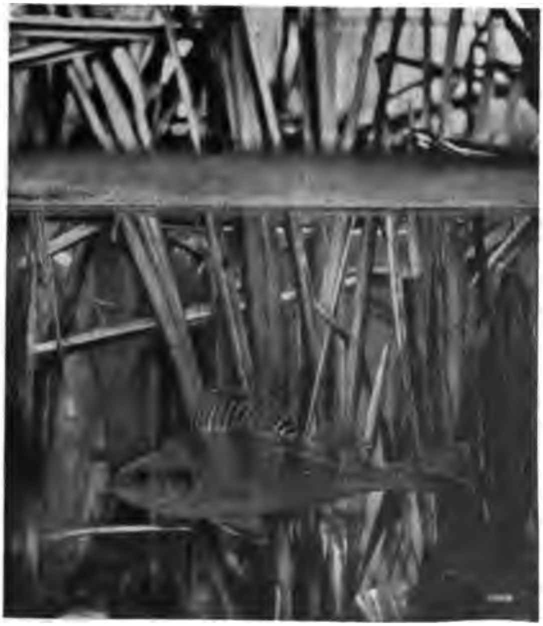
The perch illustrates the value of reed-like markings, for, in addition to his dark back and white under-surface, he is crossed by five or more bars, as shown in the illustration of a perch photographed in a tank by a front light. When seen under natural conditions, the dark back and white under-surface again become of a uniform shade. This uniform shade in itself would render the body of the perch conspicuous by interrupting the reed scenery beyond. But the markings break up the uniformly shaded body of the fish, and at the same time merge with the pattern formed by the reeds.

Water has a bluring effect, and when a perch is seen through two or three feet of this medium, the bar markings do not appear to be on the fish at all, but to be part of the reeds themselves. As a result, the eye of the observer is not arrested by the form of the fish, but is carried to the reeds beyond, and thus the perch escapes detection.

Thayer, the American artist and naturalist, in his exceedingly interesting book "Concealing Coloration in the Animal World," has brought into prominence this principle, of how the dark back and lighter under-parts



PERCH AS WE SEE IT IN A TANK.



PERCH AS IT APPEARS TO OTHER FISH IN NATURAL ENVIRONMENTS.

of an animal, when seen as in nature, make the body appear of a uniform shade, how the markings on this uniformly shaded body appear to be part of the scenery around, and how, in consequence, the animal fails to arrest attention.

Thayer generalised on fishes, and gave no illustrations, but I think the photographs shown in the present chapter fully confirm the correctness of Thayer's theories, at any rate as regards fishes. But neither Thayer nor any other writer attributes sufficient importance to reflection as a factor in concealment, and for this reason I have dealt with reflection at considerable length.

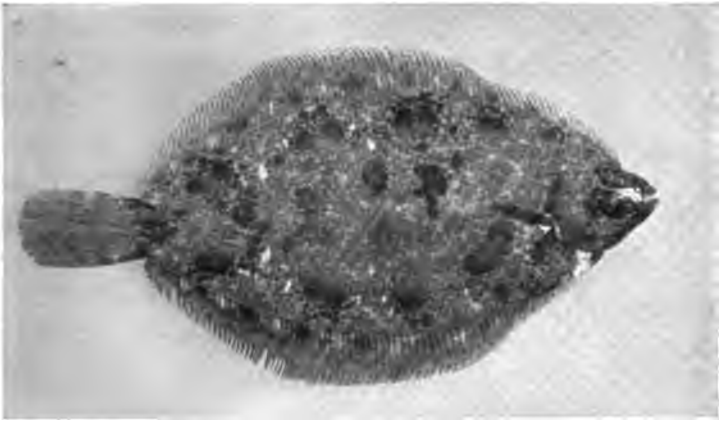
It might be thought that though the bars effectively conceal the perch when seen among reeds, they would make him conspicuous in open water. From my observations of perch swimming in the pond, it is remarkable how little such is the case. The body of a perch is so perfect a reflector that it takes the exact shade of the water around. It is almost impossible to detect the outline of the fish, and, when looking at it through any depth of water, you see merely a few dark shadows moving along, such as might be caused by reeds or weeds carried down in the stream.

Next let us consider the lemon sole as a type of the flattened fishes which pass most of their time lying on the bottom. The under-surface being out of view needs no protection, and so is colourless. On the back the pigment cells are arranged so as to simulate exactly the stone and sand markings. After the lemon sole had been photographed against a white background, it was allowed partially to bury itself on a sand-bed, and the second illustration well demonstrates the completeness of its protective markings. It is very noticeable how the brilliant white spots are quite as useful in concealing this fish as the dark blotches.

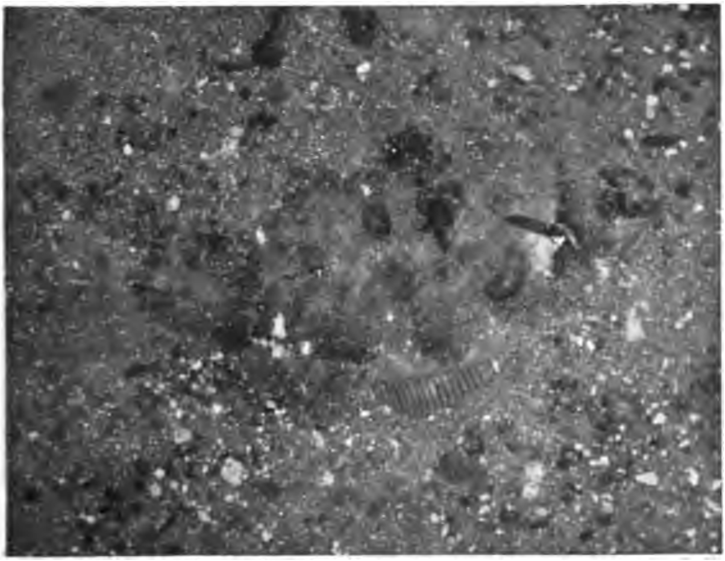
In all the different shadings and markings described the object has been to make the fish inconspicuous, so that it does not arrest the eye. Another form of protection is mimicry. In mimicry the fish is detected, but is mistaken for something else, and so left unmolested. The best illustration in our waters is that of the long pipe fish, which is mistaken for a blade of sea grass as its body sways in the water. A better illustration still is to be found in the sea-horse of Australian waters. The skin of this fish is prolonged into branched tags, which are shaped and coloured like the seaweed amongst which it lives.

We have alluded to the fact that fish, to suit their surroundings, become rapidly light or dark by the contraction and relaxation of existing colour cells. Next let us consider how by a gradual process old colour cells disappear and new ones are formed, so as to alter entirely the colour and markings on a fish should he require an alteration in his markings to protect him in new surroundings.

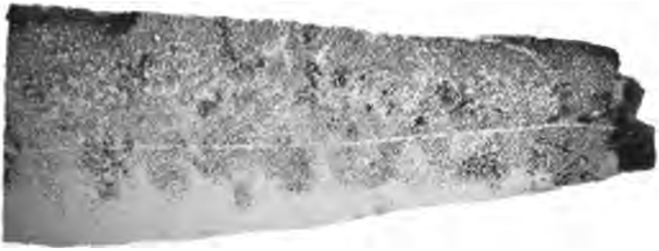
As an example let us take the stone loach. This soft, luscious, defenceless little fish, preyed on by beasts, birds and its own predatory kindred, is to be found in every



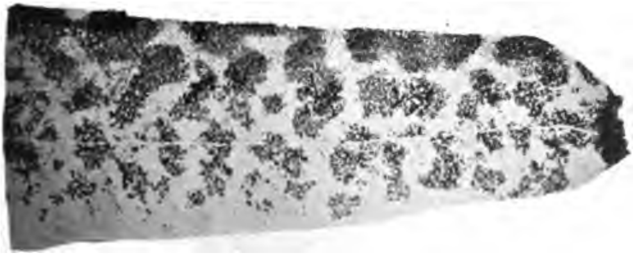
LEMON SOLE SEEN AGAINST A WHITE BACKGROUND.



THE SAME FISH IN NATURAL SURROUNDINGS.



SKIN FROM A STONE LOACH LIVING ON A MUDDY BOTTOM (*magnified*).



SKIN FROM A STONE LOACH LIVING ON A SHINGLY BOTTOM (*magnified*).

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limpid brook and gurgling stream from the Malay Archipelago to the West Coast of Ireland. Probably the loach depends for his survival over so wide a distribution on exceptional powers of adapting his markings to new surroundings. As an illustration of the usual markings on a stone loach, look at the middle photograph on the plate that precedes p. 81.

Next look at the skins of two loach on the accompanying plate. The first is a photograph of the skin of a loach caught in a brook where the bottom was muddy; the second came from the same brook several miles higher up, where the water rippled over gravel.

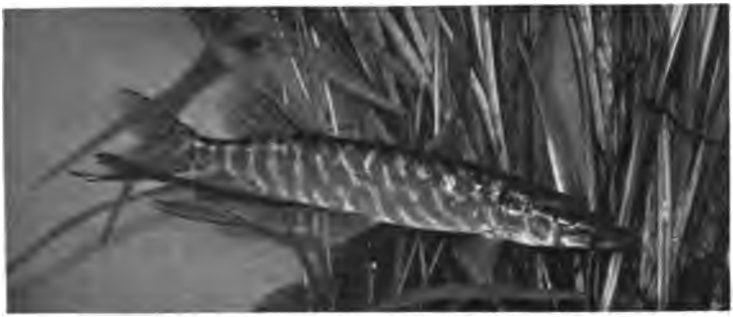
In the first the pigment cells have increased in number, and, instead of the usual spotty appearance of the skin, the colour is much more uniform, in order that this fish may the better be concealed on a dark, dirty bottom. In the second the spotty appearance is exaggerated, and even the back has quite clear spaces upon it—an arrangement of pigment that is more suitable to a gravelly bottom.

In some fish the markings invariably change during the life of an individual. This is so in the pike. The body of the young pike is crossed by several brilliant yellow bars, and lying hidden amongst the reeds these bars protect him in much the same way as the bars protect the perch. He can thus catch his prey and also escape falling a victim to his enemies.

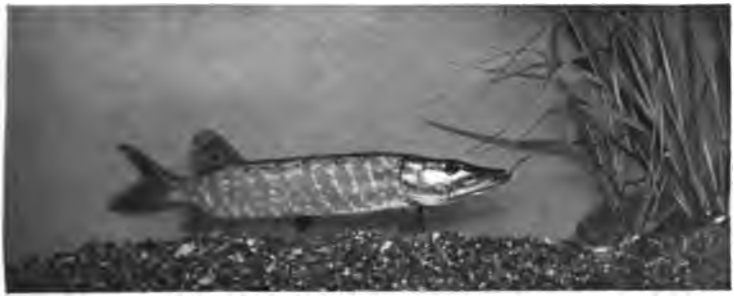
When the pike is nine inches or more in length, the yellow pigment cells disappear at regular intervals along the bars, and so the bars are gradually changed into spots. With increasing size the pike leaves the reeds at the side of the pond or river, and lies on the bottom in open water. Here his spots conceal him, whereas yellow bars would reveal him.

I would briefly refer to the photographs of the three pike on the plate facing this page. The top illustration was one of the first fish photographs I ever took, now some ten years ago, and I would draw attention to the fact that the reeds around the fish are not those of a water plant at all, though at the time I thought they were, in consequence of the land being flooded where they grew. The middle illustration, in addition to showing the bars changing into spots, is one of the best illustrations I ever obtained of a pike advancing to attack its prey. The back is perfectly straight, and the screw-like movement of the caudal fin, by which the fish slowly propelled itself forward, is well suggested. The bottom illustration is that of a dead twenty-one pound pike.

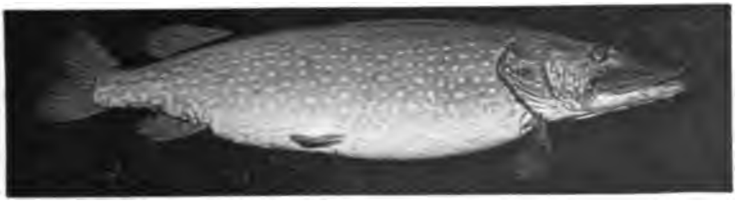
It is not necessary that concealing colours should be dull. Rocks, weeds and stones in our rivers and in our seas are mostly of a sombre hue, and so our fishes, with very few exceptions, are not brilliant in colour. In tropical waters, however, fish vie with the most gorgeous of birds in their appearance, and crimsons, carmines, blues, greens and yellows, arranged in bars, bands and blotches, assist in concealing these gaudy fish among the corals and brilliant sub-aquatic scenes of those regions.



BABY PIKE SHOWING BARS.



PIKE WITH BARS CHANGING INTO SPOTS.



DEAD PIKE, 21 LBS. IN WEIGHT, SHOWING SPOTS.

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A few brilliant fish, however, are found in northern waters, the most noticeable being the wrasses. Among our own freshwater fish brightness is given to roach, rudd, perch, by their brilliant red fins. The brilliant fins may serve as a means by which these gregarious fish recognise each other, but recently I have noticed that in the spring-time the young shoots and roots of the common rush are exactly the red of the roach, rudd and perch fins. At this time of the year the fish spawn among the reeds, and there is no doubt that the red fins, which at this season become still more brilliant, assist in concealing the fish, just when concealment is most required.

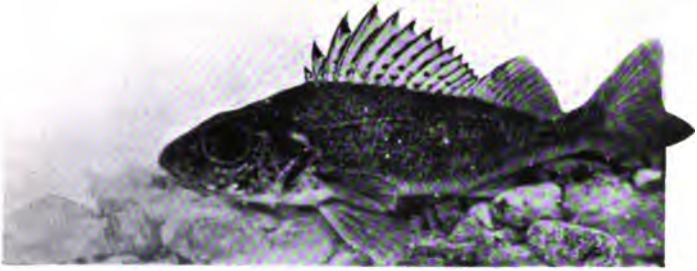
Bright colours also occur among fishes other than for concealing purposes. For example, the male becomes bright in order to make himself attractive to the opposite sex.

Though fish depend mainly upon concealing coloration for success in the struggle for existence, we must not forget that agility, size, weapons of defence, and warning attitudes all play their part.

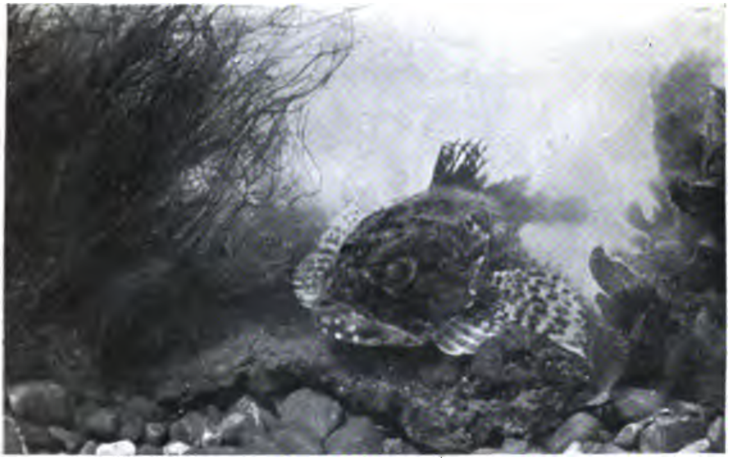
Weapons of defence frequently take the form of some modification of the fins. In the ruffe, for example, the rays of the first dorsal fin end in formidable spines. When this fish was photographed, he invariably erected his fin as I approached the tank, as shown in the illustration.

Many fish, in addition to being armed, take up terrifying attitudes when alarmed, and thus warn off their enemies from attacking them. The cottus, or father-lasher, when alarmed spreads out his large pectoral fin, erects the fins on his back, and puffs out his cheeks. The fin rays terminate in sharp spines, and the gill-covers are also armed. The cottus would be an uncomfortable mouthful, and is in consequence left alone.

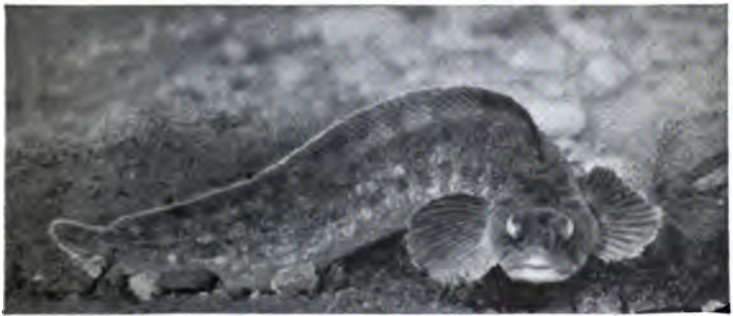
Alongside the cottus, in the sea, is found a soft, slimy, defenceless fish, the blenny. The blenny, when attacked, assumes an attitude quite as ferocious in appearance as the cottus, and as he is not specially active, nor exceptionally protected by colour or markings, we may fairly assume that this ferocious attitude deceives his enemies, and assists in his escape.



RUFFE. SHOWING THE FIN ON THE BACK AS A WEAPON OF DEFENCE.



COTTUS IN WARNING ATTITUDE.



BLENNY ASSUMING A WARNING ATTITUDE.

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CHAPTER IV

SHARKS, DOG-FISHES, SKATES AND RAYS

It may come as a surprise to some of my readers to know that there are seventeen different kinds of sharks to be met with in our waters, the largest being the hammerhead, which reaches twelve or thirteen feet in length. On the Cornish coast the blue shark frequently breaks up the fishermen's nets, and robs their lines of bait. This fish when hooked turns over and over, and twists the line round his body, so that he is gradually brought right up to the surface. The thresher shark may be seen from the cliffs, feeding on herrings and pilchards. Frequently, in order to round up a shoal of pilchards, he lashes the water with his tail, and when the terrified fish are herded together he works sad havoc among them. Some smaller members of the shark tribe are known as dog-fishes, of which the row-hound is the commonest. This scavenger of our seas appears to be everywhere, and no food comes amiss to him, and to the fisherman he is a perfect pest. Row-hound is a corruption for rough-hound, for the skin on this dog-fish, like other sharks, is covered with fine teeth-like scales. I remember taking a row-hound out of a tank on a cold day, with my sleeves turned up. The powerful fish twisted his body round my bare arm, and literally rasped off the skin, and for a fortnight after, when I dipped my arm in sea-water, I was reminded of that fish!

In the illustrations of the dog-fish shown, the shape and general character of the shark family are well illustrated. Note the position of the mouth, the long slender body, so well adapted for moving rapidly through the water, and the powerful tail, of which the upper lobe is much larger than the lower.

I have already referred to the manner in which the female dog-fish attaches her eggs to the seaweed. One of the illustrations shows her swimming round a rock. This fish deposited an egg a few hours after the photograph was taken.

Of skates and rays we have several kinds, but the common skate and the thornback ray are those usually met with. These fish pass most of their time near the bottom, swimming about with an undulating movement of the large wing-like fins, one on each side of their flattened bodies.

Their diet consists mainly of crabs, oysters, whelks, mussels, small fish and the young of the plaice and sole. Not infrequently herrings and other surface-swimming fishes have been found inside the stomachs of larger rays, and because of this it has been stated that rays sometimes feed near the surface. This is very unlikely, for I am sure the clumsy ray could only catch the herring when that fish was unaware of its presence. The probable explanation is that occasionly herring

A DOG-FISH.

FEMALE DOG-FISH SWIMMING ROUND A ROCK.

feed on the bottom, and when intent upon their food they do not notice the flat, colour-protected ray. Suddenly the ray raises itself up and flops on to the top of the herring, and before the victim can extricate himself he has been seized in the horny-lipped mouth of his aggressor.

Sharks and rays have many characteristics in common, and they differ from bony fishes in having a gristly or cartilaginous skeleton. They also have five separate gill slits on each side of the head, instead of the single gill opening behind the protecting gill cover. Many sharks and rays are born alive, whereas the young of bony fishes, with very few exceptions, hatch from liberated eggs.

Lastly, the embryos of sharks and rays possess external gills, similar in appearance to those of a tadpole, but these disappear in the thornback about four months before hatching.

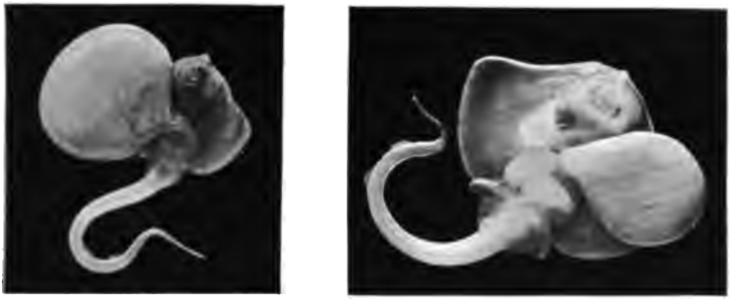
As we shall be considering the early life histories of several fishes, let us look at what happens when an egg has been fertilised. On the yolk of every egg is a spot known as the germinal area, and from this germinal area the little fish develops. The rest of the yolk is used as food to nourish it, both while it is in the egg and also after it has hatched, until such time as it is able to find its own food. The yolk food enclosed in a yolk sac is nature's feeding bottle, and is attached to the body of the little fish. We have seen how the egg case of the thornback ray is fixed to the weeds on the bottom. At first the yolk sac fills up most of the egg case, but as time goes on the embryo ray absorbing the food from the sac grows in size, and the sac diminishes in proportion.

In the photograph of embryo thornbacks removed from the egg case, the growth of the young fish at the expense of the yolk sac is well illustrated.

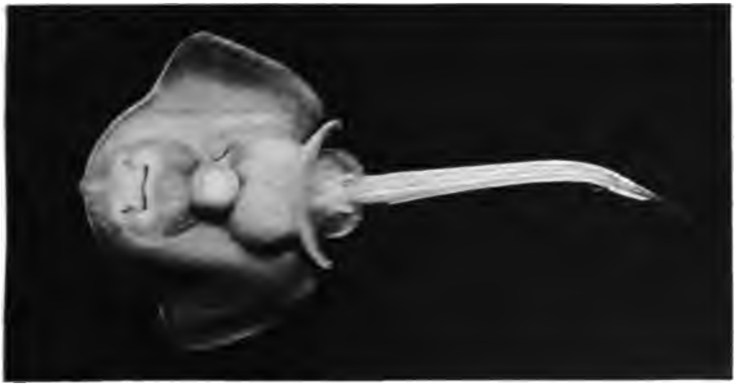
As soon as a fish hatches, it enters upon the larval stage, and, as will be seen later, the appearance of the larvæ of bony fishes, such as the salmon, roach and plaice, is totally unlike the parent fish, and the yolk sac is only partially absorbed when they leave the egg. The ray, however, when he emerges from the egg case is a perfectly formed fish, and very little remains of the sac. The back is already coloured and marked so as to render him inconspicuous on the bottom, and protect him while he is still of tender age.

The under-surface is colourless, for lying on the bottom there is no need for this part to be concealed. The yolk sac has practically gone, the fins are as they will appear in after life, and the mouth being open, the young ray is able to feed at once. The gill slits are seen on each side of the middle line, between the mouth and the remains of the yolk sac. At fourteen days old the black spots seen on the back of the newly hatched ray blend together, and give it a more uniform shade.

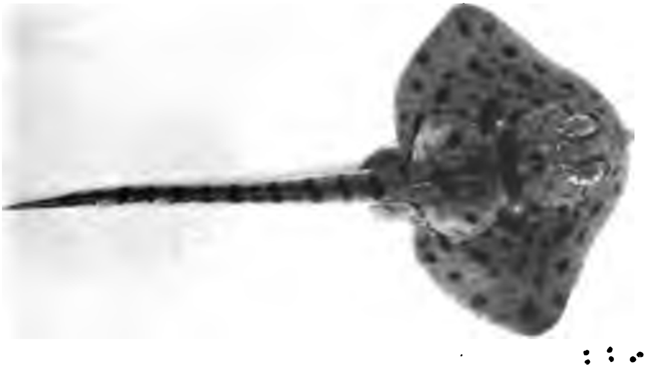
The top photograph of the accompanying plates shows a ray three weeks to a month old, and it will be seen that there are several rings round the edge of the large fins.



Two months before Hatching. One month before Hatching.



Just Hatched. Under-surface.



Just Hatched. Back.

GROWTH OF THE EMBRYO RAY.

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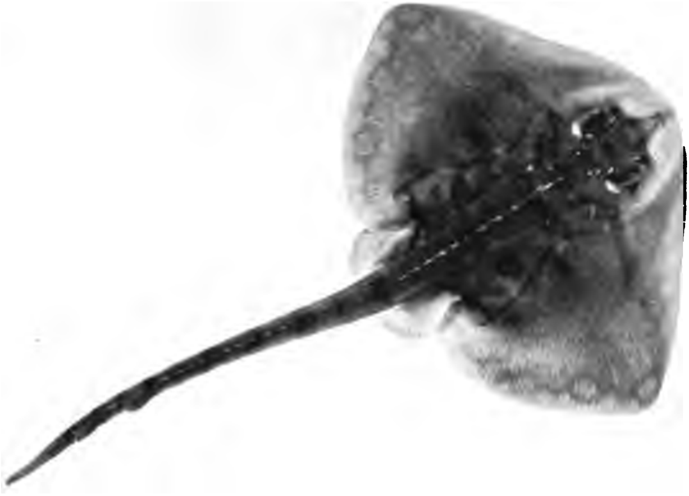
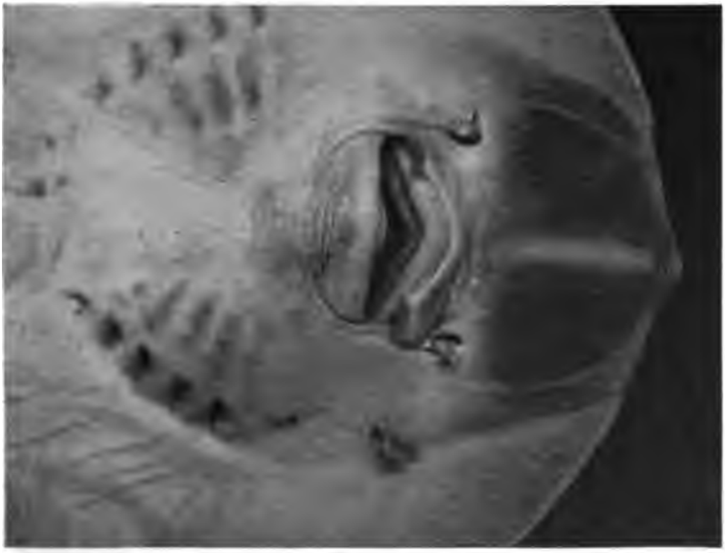


RAY, ONE MONTH OLD.



UNDER-SURFACE OF RAY, SHOWING MOUTH, NOSTRILS AND GILL SLITS.

These rings assist in concealing the sharp-cut free edge of the fin among the round stones on the bottom. The ray under consideration is the same fish as that shown on the plate facing p. 44. Here several rings are again clearly seen on the edge of the fins, but if the ground is examined other rings of a similar appearance will be detected. These are due to the stones on the bottom, for when looked down upon from above the stone forms the centre of the ring, and the shadow itself the dark ring round it. Similar rings can easily be seen if round stones are dropped into a deep tub so that the light falls on them only from above.

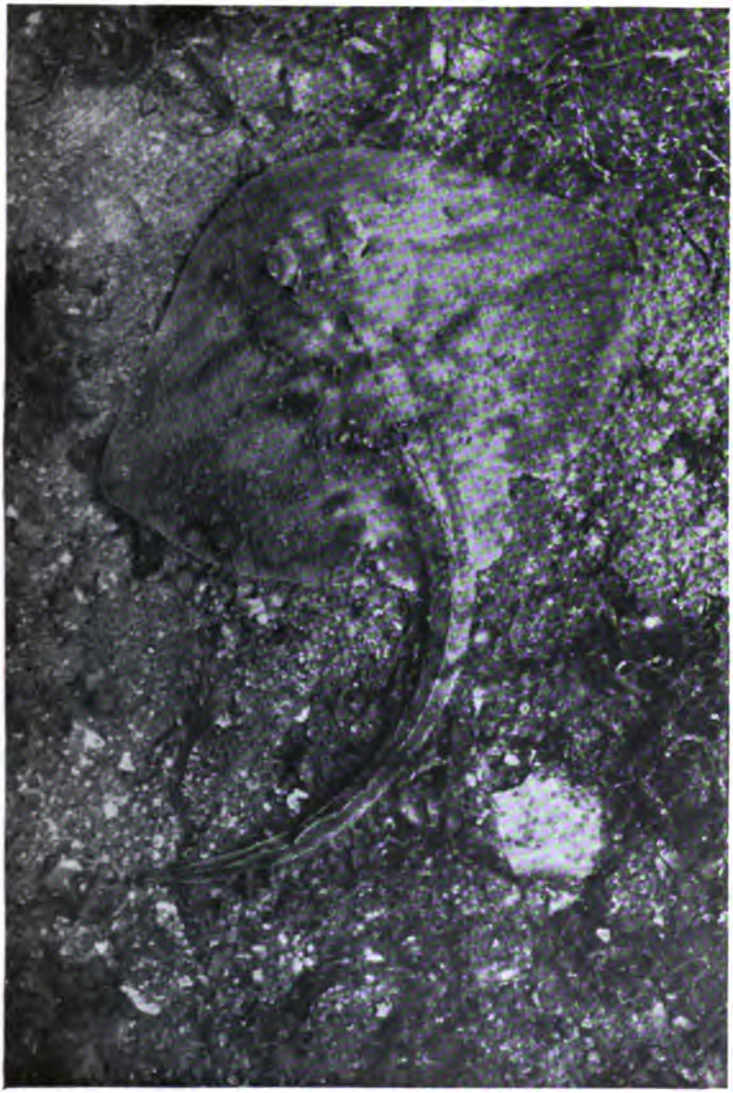
Sharks and rays are classed together, and it seems strange that fish so very different in their shape and habits should be so nearly related; but this dissimilarity in external appearances in nearly-related species is constantly met with. Sharks and rays are among the most ancient of fishes, and probably had a common ancestor. Some of these took to active life, chasing and devouring swimming fishes, and hence they became elongated in shape, and developed powerful tails. Others became bottom feeders, and by a gradual process of evolution, extending over countless ages, they became flat, and as their habits of feeding do not necessitate rapid movement, the tail as a swimming organ became functionless.

The manner in which rays are flattened is of interest, since it differs from the method of flattening of the so-called "flat fishes," such as the plaice and the turbot.

The ray is flattened from above downwards, and when divided with a knife down the back from the snout to the tip of the tail, the two halves are similar in their structure, and in the organs they contain, the wing-like fins on either sides being the modified pectoral fins, which have extended along each border.

The flat fish, on the other hand, has been flattened from side to side, so that when divided in a similar manner the back with its muscles would be in one half, and the organs of digestion in the other half. Later, when considering the plaice, we shall see how this fish starts life as a rounded larva, then becomes flat, and falls over on its side.

Flattening and coloration are not the only means of assisting the ray in the struggle for existence. The sting-ray is armed with a murderous barb, near the end of the tail, with which he is able to inflict a terrible wound; the torpedo ray is able to paralyse fishes by giving them an electric shock, and all rays possess sharp spines on their backs. The thornback ray is particularly well armed with these spines, hence its name.



YOUNG THORNBACK RAY LYING ON THE BOTTOM OF THE SEA.

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CHAPTER V

THE SALMON FAMILY

The members of the salmon family are elegant in shape, and they all possess a distinguishing feature by which they can be recognised. This feature is a modification of the second fin on the back, which has been so altered that it merely consists of a fold of skin containing fat, and is known as the adipose or fatty fin. On the plate facing p. 46 some members of the salmon family are shown, namely, the smelt, the rainbow trout and the brown trout, and this adipose fin is clearly seen in each case.

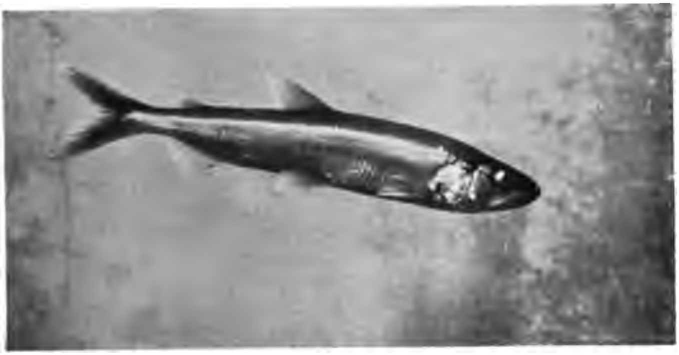
In a group of fishes so large as the one under consideration, many species are naturally described.

First and foremost are the salmons themselves, which include the salmon (*Salmo salar*) and the various trouts. Then there are the brilliantly coloured chars, found mainly in Switzerland, Ireland and Lake Windermere. The smelt is a member of the salmon family; and further, a small smelt found on the coast and in the rivers of New Zealand is the only salmon inhabiting waters out of the northern hemispheres, except for those which have been recently imported by man.

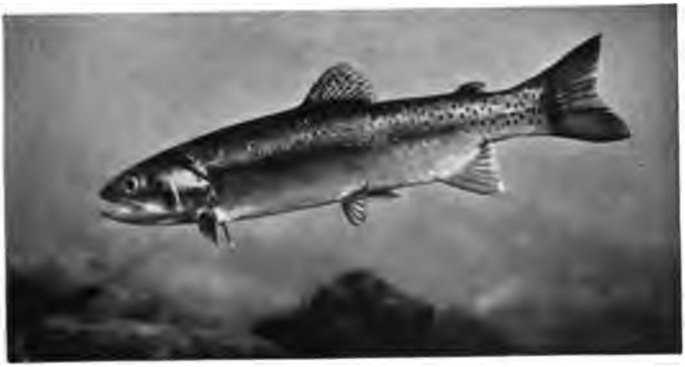
The graylings, which give excellent sport, are well known in this country and in Canada; and last, but not least, there are the numerous " white fishes " which are present in every lake and river throughout North America. The white fishes differ from other salmonoids in having large scales and delicately shaped mouths; the best known representative of this group in our country is the pollan of Irish waters. It is well to remember that in America the term " white fishes " applies to these large-scaled members of the salmon family; but at home it refers to the silvery section of the carp family, such as the roach, rudd and dace. Though the salmons are of great importance as a food supply throughout the northern hemispheres, yet it is mainly as a sporting fish that they appeal to civilised man.

Until recently the brown trout, the Loch Leven trout, the Great Lake trout (*Salmo ferox*) and others have been described as different species of the salmon family; but these fish are merely varieties of the common brown trout (*Salmo fario*). The variations in size and appearance are due to alterations in environments and in feeding habits.

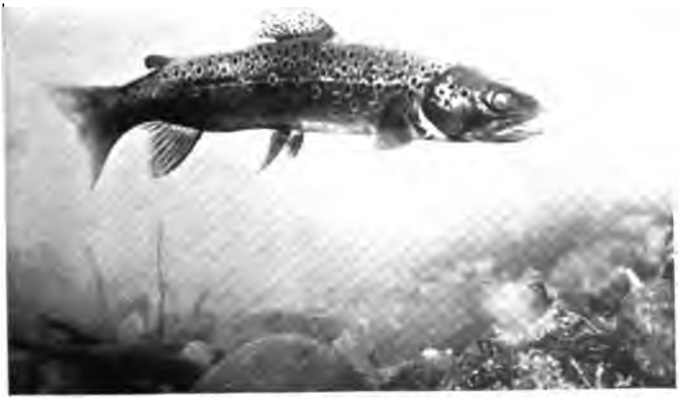
Further, the completeness with which the brown trout can acquire the appearance and habits of a migratory salmonoid suggests that at no very distant date the sea trout, and possibly the salmon itself, was a brown trout. The facts in support of the suggestion that the various trouts, migratory and otherwise, and possibly the salmon, have a common ancestor in the brown trout, are as follows :—



SMELT.



RAINBOW TROUT.



BROWN TROUT.

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These fish during the early part of their lives are almost identical in appearance, and for the first year or two possess bars across the body known as parr marks. These parr marks probably persisted throughout life in the primitive trout; even now they are permanently present on the mature trout of the Scottish burn, where food is scarce. Their spawning habits also point to a common freshwater ancestry, for salmon, sea trout, and brown trout that have acquired the habit of going to sea return to fresh water to spawn. Neither will the eggs of these fish live in sea-water.

As illustrations of the possibilities of variation in the brown trout, let us consider the Loch Leven at home, and the brown trout as he now appears in Tasmania and New Zealand.

The Loch Leven trout, with its silvery sides and black cross marks, turned into a southern trout stream, in two or three months changes his colour and markings, and is difficult to distinguish from the common brown trout.

Brown trout introduced into Tasmania and New Zealand at first maintained the characteristics of our trout at home. Now these fish weigh twenty to thirty pounds, migrate to sea and return to fresh water to spawn, and in appearance are as silvery as a salmon. The young, however, of this altered brown trout during the first year of life cannot be distinguished from yearling brown trout as seen at home.

In view of the above facts, let us look at the life history of the brown trout as a type, and then consider how environment and food supply have so greatly altered this fish in size, shape and markings as to make him appear in the guise of the migratory salmonoid, the Great Lake trout, the gillaroo and others.

The brown trout is to be found in waters of very varied description. He may have to dart after every particle of food and passing fly in a barren Highland burn, or he may be able to pick and choose his food in a lake teeming with insect life. Whichever is the case, when the autumn arrives instinct tells him that there are other duties in life besides feeding, and so he gradually makes his way to the spawning beds upon which the eggs are deposited.

After the summer droughts the water is probably low, and the trout is prevented from getting to the gravelly bed he knows so well, and with many others is compelled to wait in the first deep pool for the autumn rain. Here he may meet a mate, and subsequently they may travel together to the spawning ground. More often than not he waits until he reaches his destination before selecting a bride.

At last the rain descends, the river comes down in flood, and the pool which the day before held many waiting fish is now uninhabited. Trout racing through the rapids and resting for a time in the pools, gradually make their way to the very source of the stream, where the sparkling water gurgles over the gravelly beds. Here the male and female fish carefully select a suitable spot. The female then deposits her eggs, which are fertilised by the male, and left buried three to six inches under the gravel.

The process of spawning consists of three different actions which are practically continuous. The female fish turning on her side, first scoops out with a fanning movement of her tail, a hollow, technically known as a "redd"; into this hollow she sheds her eggs. She then moves forward, and continuing to throw up gravel with the fanning movement of her tail, covers the eggs already deposited. In this manner several hundreds of eggs are buried over an extensive area. During this time the male fish is quite near, and fertilises the eggs while they are covered over. This process of spawning is generally spread over a period of two or three days.

Not infrequently I have met people who thought that the male fish assisted in grubbing up the gravel with his snout, and that this habit accounted for the hook on his lower jaw; but this is incorrect. The male fish takes practically no part in making the redd or in burying the eggs.

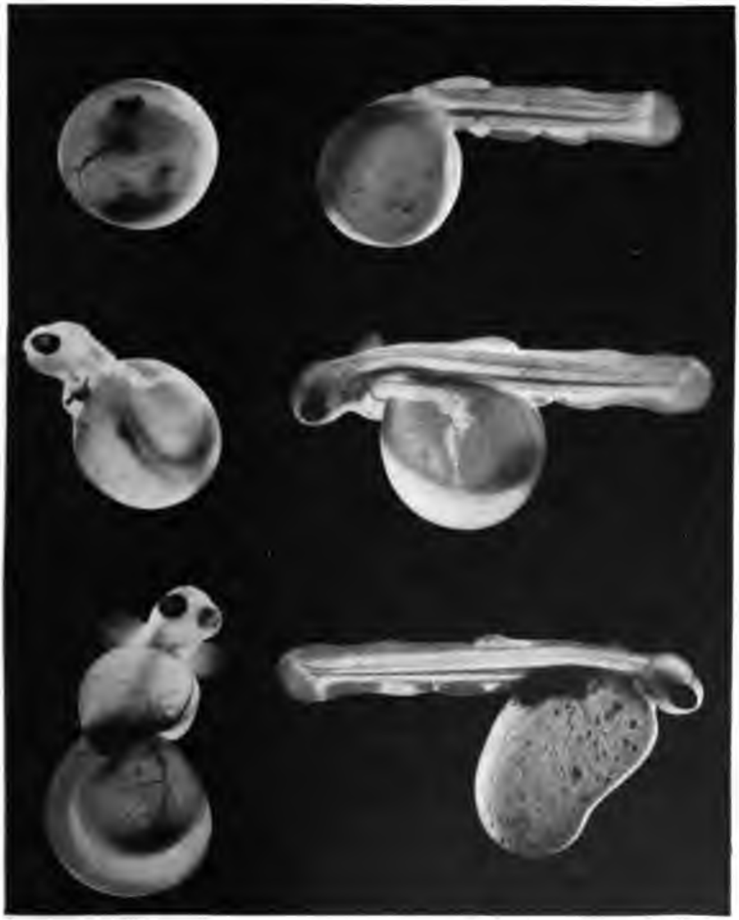
Her duties accomplished, the female trout gradually drops down into deeper waters, lanky and out of condition; but the male, as a rule, stays about for a time on the edge of the spawning ground, and descends to the deep water later in the year.

The length of time before the eggs hatch depends upon the temperature of the water, but usually the ova lie for about three months in the gravel. During this time the sparkling water, making its way in little eddies among the stones, carries oxygen to the developing embryo.

In six weeks two little black dots appear in the egg, which are the eyes of the fish; and in another six weeks the young trout is ready to hatch. But for days before this the prisoner had found his quarters too confined, and had been wriggling and struggling to get free. After a specially violent effort, the egg membrane splits and the delicate tail appears. Next the back and the head of the fish escape, and finally the encasing "shell" slips off the yolk sac. Strong, healthy fish usually hatch in this manner, but not infrequently the head and shoulders appear first, and occasionally the yolk alone protrudes as a constricted bladder. When this occurs, hatching is always delayed, and not infrequently the young fish dies in the egg. On one occasion, while I was watching salmon hatch, I picked out an egg with just a round bead of yolk sac protruding, and placed the egg in the photographic tank; presently the head and shoulders also shot through, giving the hatching fish the quaint "jack-in-the-box" appearance shown on the opposite plate.

Hatching with the yolk sac nipped in, as shown, took a long time, and all the while the young fish kept up a continual fanning movement with his pectoral fins, the object of which will be referred to later.

The larva of the salmon family when first hatched is known as an "alevin," the name being derived from a French word meaning a young fish.



HATCHING OF THE SALMON.

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We have presumed that all has gone well with the eggs left in the gravel, but in nature only a small percentage of the eggs deposited result in the birth of an alevin. Sometimes the eggs are insufficiently covered, and being washed out of the redds, they are quickly devoured by young trout, always to be found on the spawning grounds. Late spawners frequently expose the eggs already deposited, and indulge in a hearty meal. Ducks, water hens, rats, eels, insects and larvæ all take their share of the spoil. Floods may cause countless ova to be buried feet deep under gravel and debris; or if the water shrinks, the eggs may be left high and dry. Finally, in a cold winter the water over the redds may freeze solid, and when the ice moves it takes with it gravel, buried eggs and all.

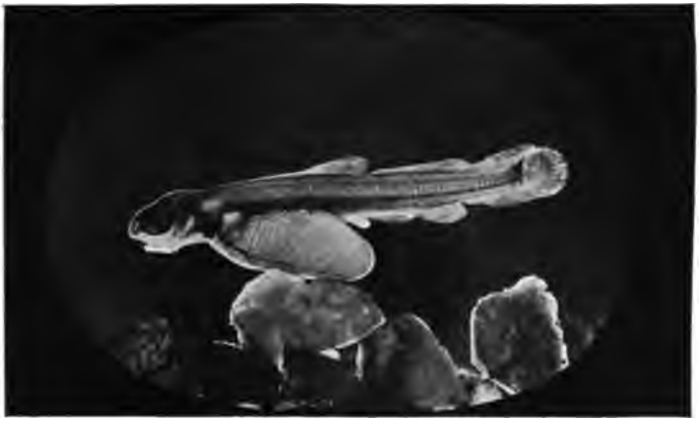
Now, to return to the newly-hatched alevin. It will be seen that a continuous primitive fin runs right round the body, but notice there are irregularities where the permanent fins will appear. The gill clefts are clearly shown, and attached to the little fish is the huge yolk sac from which it derives its nourishment for five or six weeks.

The left side of the yolk sac is seen in the illustration of the salmon just hatched. The dark mass at the upper part is the liver, which is of a deep salmon pink colour; the round objects are oil globules, and the network over the yolk sac is a mass of small blood-vessels. In the photograph of the alevin with its head just hatched, the heart is clearly seen, and the curved dark line of its body shows the wriggling movement of the fish as it endeavoured to escape.

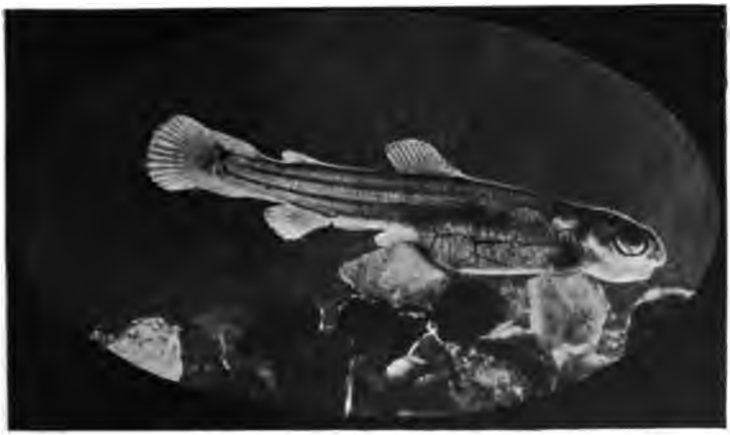
At first the alevin, exhausted with the exertions of escaping from its shell, lies panting on his side, but soon he takes up a comfortable position in the gravel, and keeps very much to this one spot, until his yolk sac is almost absorbed. Alevins are not gregarious, and avoid each other; they also dislike the light, and when covered with insufficient gravel they burrow deeper among the stones.

I have already alluded to the continual fanning movement of the pectoral fin, which commences even before the alevin is completely hatched. The result of these continual fin movements is to make a current round the little fish as he lies buried deep in the gravel, thus removing the water vitiated by his breathing.

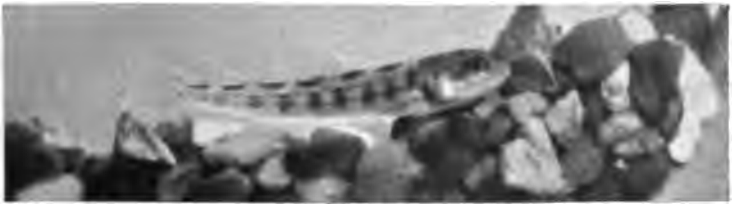
When trout are bred artificially, large numbers of alevins are kept in hatching boxes, and here the fish, when healthy, crowd together or "pack" in the dark corners. This packing is due to the instinct which makes them seek shelter, and as there is no gravel for them to hide in, they hide amongst themselves. An incidental result of this packing is, that a steady current of water is maintained round the fish, for every alevin as he lies shoulder to shoulder with his neighbour, keeps up the continual fanning of his two large pectoral fins as already explained, so that the polluted water is swept on in a steady stream, to be replaced by a fresh oxygen-laden supply.



BROWN TROUT TWO WEEKS OLD (*magnified*).



BROWN TROUT FIVE WEEKS OLD (*magnified*).



SALMON FRY SEVEN WEEKS OLD, SHOWING EARLY PARR MARKS.

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To return to the alevins in the gravel, at first the mortality amongst them is not great, but as soon as they begin to move about and get under the larger stones, their enemies play havoc amongst them. Sticklebacks and other small fish hunting in the gravel take their share, murderous-looking larvæ and caddis worms crawling into the darkest recesses still further diminish their numbers; and their constant enemy, the eel, is always on the look out for them.

At five weeks old the alevins have acquired a more fish-like appearance, the fins are quite distinct and the adipose fin prominent, but notice that the tail fin is very unlike that of the adult trout. Though the alevins still derive some nourishment from the yolk sac for another week or two, they now begin to swim, and start feeding on minute infusoria. Next, the little fish tackle the young of tiny crustaceans, such as the cyclops and daphnia, or water-flea. At seven or eight weeks old the fins are separate and the yolk sacs have disappeared, and the alevins are now dignified by the name of "fry." Cyclops, daphnia, water-spiders, small beetles, larvæ of water-flies, and young snails are now added to their dietary, and occasionally they are able to nip off the heads of their old enemies, the caddis worms, before these insects are able to withdraw into their protecting cases. If fortunate, the alevins come across a water-cress bed, where freshwater shrimps abound. The young of these crustaceans afford the best of food for fry, and on this nourishing diet they soon grow fat and strong.

As a rule, fry dart here, there and everywhere in search of food, but occasionally several of them will band together and systematically hunt *corixæ* (water beetles not unlike water-boatmen, but smaller in size). The *corixa*, though small, is a valiant fighter, but as soon as the young fish succeed in nipping off one of his oars, he is at once disabled and at their mercy. Then falling on him like a pack of hounds, they tear him limb from limb.

These foraging excursions soon add to the size and strength of the alevins, but they also materially add to their chances of destruction. At every corner a hungry trout or some other fish is ready to snap them up, the gaily painted kingfisher is on the look out for them by day, and at night they have to avoid one of their worst enemies, the eel.

With the autumn, the adult mature trout again comes up into the shallow water to spawn, and now the fry have a lively time in picking up stray eggs, and in avoiding the attentions of the hungry fish after they have spawned. By the following spring the fry have grown from three to seven inches in length, according to the abundance of their food supply, and are known as "yearlings." During the summer these yearlings drop down into deeper waters, adding considerably to the variety of their food, and to their already long list of enemies.

In another year's time the trout has grown so that he is now from five to twelve inches in length, and is known as a "two-year-old."

In the autumn of her third year, the female trout goes up to the spawning ground to deposit her eggs. Here she will receive the attentions of a male fish, many of whom are already on the ground. Sometimes quite a small male will mate with the female, but if the trout are present in any numbers a larger fish is sure to drive him away, and then the smaller fish will have to try his luck with another mate. Should, however, the two cock fish be about the same size, a lively battle will ensue, and often the scales are torn off their backs as they viciously bite each other.

As a young fish, the trout at the spawning season becomes of a dark shade, but the colours are very intense and the red spots on his body more than usually brilliant. Later in life the trout ceases to put on this intense coloration, and instead the skin becomes spongy and partially overlaps the scales.

In consequence of his numerous enemies, a trout seldom reaches old age, but when he does so, he loses his symmetry of form, for the body wastes and the fish appears to be all head, while the lower jaw is prolonged upwards as an ugly hook.

We next turn our attention to the salmon. There are many reasons why this fish excites such general interest. He appeals to the fisherman because he is the prince of sporting fishes. His elegance of shape and delicate silvery hues please the man who has an eye for beauty, and the fact that his pink flesh goes so well with sauce and cucumber undoubtedly adds to his popularity. But it is the mystery that has long enshrouded the life history of the salmon that makes him the centre of attraction to those interested in fish ; a mystery that is being slowly unravelled.

The salmon is probably a fish of freshwater origin that has acquired the habit of going to the sea in order to obtain a more abundant food supply than is possible in lakes and rivers. He returns from the sea to spawn in fresh water, but there is evidence to show that not infrequently salmon come into the rivers and return again to the sea without spawning. This may be due to a homing instinct on the part of the fish or to the fact that, having fed to repletion in the sea, he returns to fresh water to rest from his gluttony.

The fish " run," that is, ascend into the rivers, during every month in the year, but they mostly go up in February and March, June and July, and in the autumn.

The persistence with which salmon will attempt to overcome every obstacle to their ascent into fresh water is well known, and given a sufficient volume of water, it is extraordinary the raging current they can swim against. The height that a salmon can leap has been greatly exaggerated, for a clear drop of five or six feet is the maximum that the strongest of fish can successfully negotiate. This fish frequently leaps into the air at other times than when attempting to overcome an obstacle which bars his progress to the spawning grounds. When the salmon first leaves the sea this apparently aimless leaping into the air may be due to his endeavours to get rid of the sea lice which cover his body, but later when these parasites have dropped off in the fresh water, it is difficult to explain the reason for his gymnastic feats, except by the fact that the fish is uncomfortable in fresh water.

It certainly does not add to the prospect of killing a fish when salmon are jumping all around; but there are few who are not fascinated by his movements.

Watch him as he leaps out of the water; frequently he shoots up as straight as an arrow, then by a quick turn he will again cleave the water with his head as neatly as an expert diver. At other times he will twist into a complete circle, sending a spray of water off his body.

In the autumn, salmon, like the brown trout, repair to the spawning beds, often going up into such shallow water that the fins on their backs appear above the surface. The spawning usually takes place in November and December, and this quite irrespective of when the fish left the sea to come into fresh water. The actual shedding of the eggs may take several days. First, the female fish lies on her side and fans away the gravel with her tail, so as to make a trench into which she deposits a portion of her eggs; the male, following after her, fertilises the eggs, which are again covered over with gravel as the fish move along. When the spawning is over, both fish, emaciated by their long fast and exhausted by the exertions of spawning, slowly drop down into deep water, and return to the sea early in the spring.

In due course the salmon alevin hatches, and at the end of five or six weeks this larval fish loses his yolk sac.

After the yolk sac has disappeared, as in the case of the trout, the alevin becomes a fry. By the autumn these fry have grown to two or three inches in length, and are then known as parr.

Salmon parr, trout fry, and the young of sea-trout are to be found in the shallow water of most salmon rivers, but they are not gregarious, and one young fish will resent the presence of another by nibbling his tail or some other part of his body.

These little fish when two or three inches in length are brightly coloured, and objects of great beauty. Each has a dark olive back, sides of the same colour, but of a lighter hue, and glittering white under-parts. The dark olive colour of the back is continuous at regular intervals with the vertical bars or parr marks across the lighter sides of the young fish. On the top of this variegated colour arrangement is seen a metallic iridescence of gold and silvery hues, and the sides are also freely spangled with black and crimson spots.

Though very similar in appearance even at this stage, the salmon parr, the trout fry and the young sea-trout can generally be distinguished from each other.

In the young salmon the head is shorter than in that of the brown trout; there are nine or ten finger marks across the body, and the adipose fin is slaty blue in colour.

The sea-trout has the same number of markings, but the adipose fin is orange tipped.

In the brown trout there are usually only six or seven finger marks, and the adipose fin is red in colour.

Salmon parr and trout fry differ slightly in their methods of feeding, for salmon parr feed mainly on food under the stones, whereas trout fry feed on food carried along in the water.

Returning to the salmon parr, we left him two or three inches long at the end of his first summer. During the winter the little fish lives in a comatose state under a stone, and takes no food. In the early spring he again emerges as a dark, lanky little fish, but as the water becomes warm, parr again assume their active habits and make their way up every little stream, and swarm in the shallow running waters of salmon rivers. During their second summer parr double their weight; but when winter arrives they again retire into shelter.

In the following spring, that is, when the parr is just over two years old, the little fish gather together in shoals, and a complete alteration takes place in their appearance, for the back becomes of a dark bluish shade, and the sides a silvery hue. The parr is now described as having put on his "sea jacket," and is known as a smolt.

The silvery appearance of the parr is due to the fact that the scales become covered with the light reflecting spicules already mentioned in an earlier chapter.

If the scales are removed from a smolt the parr markings, due to the arrangement of pigment cells in the skin of the little fish, are seen as clearly as ever.

In April and May the smolts drop down into the sea and disappear.

It has been comparatively easy to watch the parr and the smolt while in fresh water, but when the smolt goes to sea it is a totally different matter.

During the last fifty years the life of the salmon has engaged the attention of scientists and fishermen, and the earlier knowledge gained about his life in the sea has been obtained by the recapture of specimens that had been marked.

At first the method of marking fish mainly consisted in cutting the fins, and this rough and ready method is probably responsible for many of the conflicting statements in the description of the life history of the salmon. Latterly, fish have been marked by means of plates or silver wire attached to the dorsal fin, each plate or wire bearing a distinguishing number, and by this means reliable information has been gained.

In addition to marking, the fact that the age of many bony fishes can be read by the formation of their scales has been made use of.

The scales consist of bony plates, which are partially buried in pockets in the skin, and they overlap one another like the tiles on the roof of a house, the free edge of the scales being towards the tail. The number of scales on any particular fish remains the same throughout life, and as the fish grows in size the scales grow in proportion so as to cover the skin entirely.

The increase in size of the scales is by the means of rings of growth, which are added round the edges, in a manner similar to the rings of growth seen in the section of the stem of a tree. It is the arrangement of these rings of growth that affords an indication of the age of a fish. During the summer, when the weather is warm and food is plentiful, the fish grows rapidly in size, the scale grows at a proportionate rate, and so each ring of growth is of considerable width. In the winter the growth of the fish is retarded, and so each ring of growth is narrow.

The outer edge of each ring of growth is marked by a distinct line. The summer growth on a scale is seen as a broad, light crescentic band, in consequence of these lines being far apart, and winter growth is shown as a narrow dark crescentic band, in consequence of these lines being close together. In this way it is possible to read the age of a fish by the arrangement of the rings of growth on its scales.

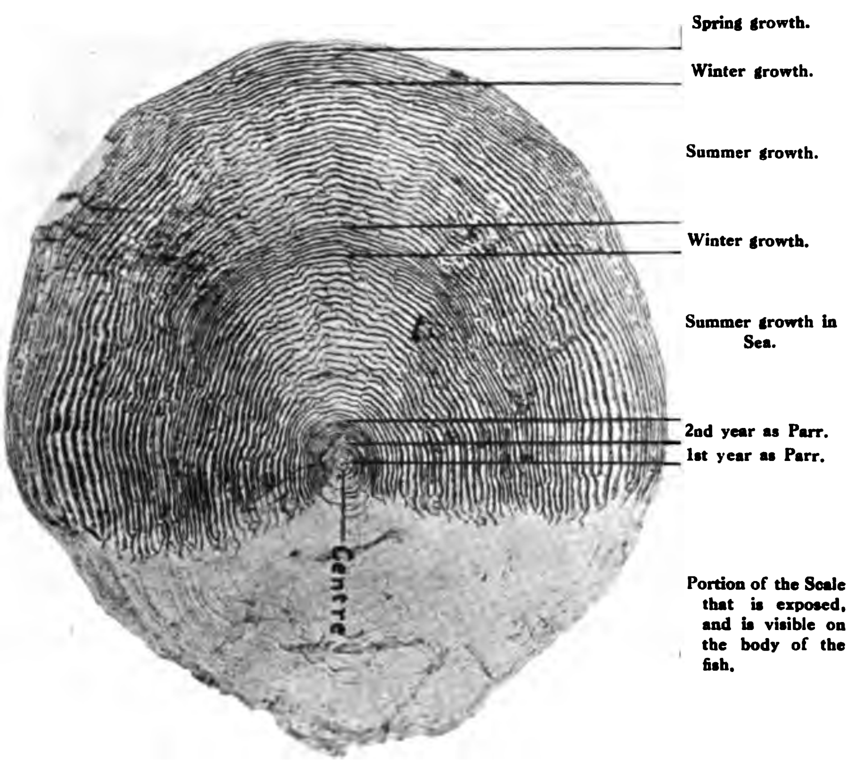
Calderwood, Johnson, Hutton, Mallock and others have thoroughly studied the scales of the salmon, and have in this, and in other ways, considerably added to our knowledge of its life history. By the scale markings it is possible to state when the smolt went to sea, how long it remained in the sea, and at what age, or ages, it returned to fresh water to spawn.

If the scale of a smolt taken in fresh water on its way to the sea be examined, about twenty-six of these rings will be found to be present.

The growth of the young fish during its life in fresh water as a parr is slight, so the rings are very narrow, though the difference between summer and winter growth can be easily recognised. If the same smolt is captured after it has been only a few weeks in tidal waters, outside the narrow rings formed in fresh water will be seen two or three broad rings. These broad rings are formed in consequence of the immediate rapid increase in size of the smolt as a result of his more abundant food supply in tidal water. During his first year in the sea the fish continues to add broad rings of growth, which gradually approximate each other as the winter approaches, and this process is repeated year by year so long as the salmon remains in the sea.

Not only can the age of a salmon thus be read, but it also is possible to tell at what age a fish returned to fresh water to spawn. This is shown by a scar or spawning mark on the scale, which takes the same crescentic shape as the rings of growth.

The spawning mark is formed in consequence of the fact that when a fish has spawned, it loses weight and its skin shrinks, but the scales cannot shrink, and so the edges fray. When the scale again grows, the frayed edge leaves a permanent scar.


Spring growth.
Winter growth.
Summer growth.
Winter growth.
Summer growth in Sea.
2nd year as Parr.
1st year as Parr.
Centre
Portion of the Scale that is exposed, and is visible on the body of the fish.

Scale of 14 lb. Cock Salmon caught in the Tay, May 8th, 1911, showing Winter and Summer growth (*magnified twelve times*).

LIFE OF A SALMON AS READ BY THE SCALE.—I.

I have chosen two photographs of scales removed from the shoulder of a fourteen-pound cock fish, caught in the Tay on May 8th, 1911.

First, let us examine the illustration of the complete scale.

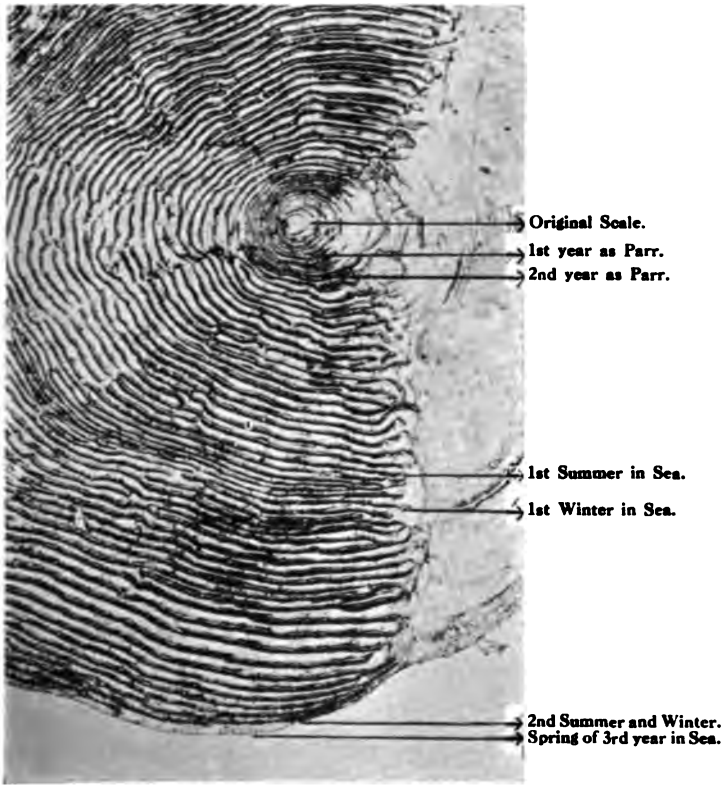
The smooth portion is that part of the scale which is visible on the body of the fish. The portion showing rings is that part of it which is buried in the skin and overlapped by adjacent scales. The broken edges, and the apparent absence of rings of growth on the smooth part of the scale, are due to the friction to which this portion of the scale is exposed. The centre of growth is seen as a complete little circle; this was the original scale on the larval fish. Round this centre are several complete rings indicating the growth of the parr during its first year. Outside these rings we have further rings due to the growth of the parr during its second year in fresh water. The lower portion of the second year rings have come on to the exposed portion of the scale, and so have been rubbed down. The rings of growth, so far, are very narrow, as the growth of the parr in fresh water is very slow, but just outside the completion of the narrow rings are seen two broader rings (though these two rings are not nearly so broad as subsequent ones). The two broader rings are due to the increased growth of the smolt in tidal water; then follow twenty-two very much broader rings, which indicate the growth during the fish's first summer in the sea; next, six narrow rings for the first winter's growth in the sea; again, twenty-two broad rings and seven narrow rings for the second summer and second winter in the sea; and, lastly, two or three broad rings for the spring growth in the sea. In May the fish was caught in fresh water.

A glance at the scales as a whole shows the summer growth in the sea as a broad light band and the winter growth as a narrow dark band.

The second illustration shows another scale from the same fish. The particular points of interest in this photograph are, the clearness with which are shown the original scale, the first and second year's growth as a parr, and the single broad ring of growth added to the scale at the commencement of the salmon's third summer in the sea.

By means of the systematic markings of smolts and other stages of the salmon, and the examination of scales carried out by numerous scientists all over the country, the life history of the salmon is now partially known.

Our present knowledge points to the facts that the salmon alevin hatches about February, and lives in fresh water as a parr for over two years, then becomes a silvery smolt and goes to sea about May, that is, twenty-seven months after he has hatched. This fish spends the third year of his life in the sea, and may return as a grilse to fresh water in his fourth year. If he returns early in the year he probably weighs two or three pounds, but if not until the autumn he may weigh ten or twelve pounds. The grilse spawns and becomes a


Original Scale.
1st year as Parr.
2nd year as Parr.
1st Summer in Sea.
1st Winter in Sea.
2nd Summer and Winter.
Spring of 3rd year in Sea.

Scale from the same fish magnified twenty-five times. This Salmon spent two years in fresh water as a Parr, then two years in the sea, and returned to fresh water, probably to spawn, in the beginning of its fifth year.

LIFE OF A SALMON AS READ BY THE SCALE.—II.

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"grilse kelt," returning to sea early the next year considerably diminished in weight.

The grilse kelt in the sea becomes a salmon, and may return in another year, though more often in two years' time, to spawn as a salmon, returning to the sea as a kelt.

Salmon seldom spawn more than twice in their lives, and they have not, up to the present, been found to return after eight or nine years of age. Either salmon do not spawn after this age, and therefore do not return to fresh water, or eight or nine years is their natural span of life.

There are many irregularities in the journeyings of a salmon. For example, fish may not return to fresh water at all until the fifth, or even sixth, year of their lives.

Salmon certainly grow very rapidly, but there has been considerable exaggeration as to their actual rate of growth. A spring fish coming into fresh water for the first time during the fifth year of life usually weighs twelve to twenty pounds, but as an exception a fish can weigh thirty-five pounds at the beginning of its fifth year; that is to say, it can put on weight at the rate of one pound per month in the sea, taking into account summer and winter growth.

A journey into fresh water to spawn of course prevents the fish increasing in weight as fast as if he remained the whole time in the sea.

The salmon found on the Pacific Coast of America, which is the fish that supplies the material for the huge "canning" industries of that country, differs somewhat from our salmon at home, and only spawns once in its lifetime, and the summer run of these fish all die after spawning.

The changes in the appearance of a salmon during its excursions into fresh water are of interest. The fish leaves the sea with a bluish-black back, and glittering silver sides dotted with black cross-marks. This is how we see the salmon, but remember, to other fish it is rendered inconspicuous by reflecting the colour of its surroundings, and by its back becoming the same tone as the rest of its body. When the silvery salmon first comes into fresh water it is covered with sea lice, and if a fish be taken with these on its body, you may be quite certain that it is only just run up, for the lice very soon drop off in fresh water.

After being a week or two out of the sea, the silvery shades of the male are replaced first by a coppery hue, and later by a rich red-brown. At the breeding season the salmon, like the stickleback, becomes brilliant in colour, his body having upon it several red and brown zigzag markings. When the female has been in fresh water for some time she assumes quite a dusky appearance. The salmon immediately after spawning is a miserable, emaciated object to look at, and is known as a kelt. The kelt, however, recovers to a certain extent in fresh water, and again becomes silvery in appearance, but never regains its comely shape until it has been to sea. The improvement in the vitality and in the appearance of the kelt is due to the fact that the entire blood of the fish is again utilised to nourish its body, instead of being diverted to a considerable extent to supply the organs concerned with the production of spawn.

It will be seen that the number of salmon in the sea and in our rivers depends upon the number of smolts that go to sea, and the number of smolts that go to sea depends upon the number of salmon eggs deposited on the redds. Salmon parr, smolts, and kelts have for some time been protected by law, but it is only recently that the importance of allowing a sufficient number of spawning fish to reach the redds has been realised. Yet it is upon these spawning fish that the whole salmon fishing industry depends. As soon as more owners of salmon nets recognise that by their persistent netting they are killing the "goose that lays the golden eggs," and that they must allow the nets to be up for longer periods than the law actually demands, so soon will our salmon fisheries improve.

Some kelts recover their vigour and silvery appearance to a greater extent than others, and these are known as "well-mended" fish.

Now kelts are a perfect nuisance to anglers who are out to kill salmon, but occasionally a well-mended kelt will often give as good sport as any spring fish.

There are two fish, the memories of which are ever before me. One was a nine-pound carp, the history of which will be given later, and the other a thirty-pound kelt, taken on the Dee.

There had been a spate, and the river was too full for successful fishing. After a tiring day, I was fishing out the last pool on the water, and as my fly swept round to within two feet of the bank, the line suddenly appeared to be checked. So near the shore, I thought the fly must have caught on a stone, but when I raised the point of the rod, to my utter surprise the line screeched out off the reel into mid-stream, and what appeared to be a mountain of silver leapt into the air. I rapidly scrambled up the steep bank behind, and there was the fish, some eighty yards away, ploughing through the raging current like a motor-boat, with the line whistling in the gale. Not even a well-mended kelt can stand a strain of this sort for long, and suddenly she turned tail and shot down-stream. Now, tearing after her, twice I fell on the slippery bank, and on one of these occasions the gillie saved the situation by quickly snatching up the rod, and following the fish until I was able to catch him up. The fish was a very demon, and at first it appeared as if her destination would be nothing short of Aberdeen, some twelve miles down the river! when suddenly she switched off into slack water just at the head of a raging rapid, where it would have been impossible to follow. It was not long now before we had her well in hand, and not till then did I suspect that it was a kelt, though, of course, my knowing gillie knew it all the time! The fish had to be brought to a very submissive state, and then the gillie waded in to make a closer inspection. This inspection confirmed our suspicions, and the kelt was tailed and lifted on to the bank. As soon as she was landed, as so often happens after a good fight, the fly dropped out of her mouth. She was a beautiful fish, but undoubtedly a kelt, so back she had to go!

For several minutes she lay quite still in the shallow water, until I waded in and gave her a touch, then with a violent swish of her tail she shot like an arrow into the deep water, to get, I hope, safe and sound to sea.

We then drank the health of the kelt and to our next merry meeting, when she came back as a clean run forty-pounder.

There are certain problems in connection with the habits of salmon which are always a fruitful source of controversy, viz. :—

Do salmon return to the river in which they hatch? Do they fast while in fresh water? If they fast, why do they take a fly or other lure?

The examination of marked fish points to the fact that salmon, as a rule, do return to the river in which they were hatched; but this is due to the fact that it is exceptional for salmon to roam far in the sea, and when the time again comes round for them to spawn, the river from which they have descended is probably the nearest fresh water.

With regard to the question as to whether salmon feed in fresh water, the evidence in support of the fact that they do not is overwhelming. Thousands of fish have been examined in fresh water, and have been found to contain no food in the stomach, nor any evidence of digested food in the alimentary tract; whereas in the sea, salmon have been frequently taken containing six and seven herrings inside them.

Further, after a fish has been in fresh water for some time, the lining of the stomach is in a crinkled, contracted state, conclusively showing that food has not been taken for some considerable time.

I attribute the non-feeding of salmon in fresh water to the fact that on their return from the sea they are ill at ease. This may be partly because they have come up to spawn and partly because the environments in a river do not suit them after their long sojourn in the sea. When a fish is uncomfortable, or does not feel at home in his surroundings, he ceases to feed, and hunger in itself will never drive a fish to feed so long as this feeling of strangeness remains upon him.

I make this statement after observations upon various wild fish turned into the pond as opposed to those received from hatcheries. As one example of these observations, I will take the case of a half-pound brown trout caught on a fly and turned into the pond. This fish hid up and sulked for four days in a patch of weeds within a few feet of where the other trout in the pond were regularly fed. On the fifth and sixth day he emerged from hiding, and swam about with the other fish, but still did not feed, although the worms, as they were thrown in, sailed right past his nose.

After being a week in the pond the brown trout under consideration took his food like the rest of the fish. By the way he now fed it was quite obvious that he was very hungry, and yet he would not feed until he was accustomed to his new surroundings.

The pond being not altogether unlike his usual habitation, this brown trout fed in a week. In the past, I have put wild adult brown trout in tubs and tanks supplied with natural food and running water, but they never became accustomed to their surroundings and refused to eat.

The fact that a salmon has come up into fresh water to spawn does not appear to me to be the main reason why they do not feed in fresh water. Early spring fish coming up into fresh water ten months before they spawn do not feed during the whole of the time, and yet a salmon that remains in the sea until the late autumn feeds freely until a month or two before spawning, and then only ceases to feed in fresh water.

Rainbow trout, dace, and roach have spawned in the pond, and all these fish fed freely the whole time.

I believe the main reason for the non-feeding of salmon in fresh water is that the change of environment from the sea to the river, and from salt to fresh water, causes the fish to be "off colour."

Salmon will lie motionless for hours together at the bottom of a deep pool with young trout and parr swimming round them. This in itself indicates that the fish feels strange, for such abstinence must be quite contrary to the usual habits of a fish that is seldom caught in the sea without being found to contain numerous herrings, haddocks and other pelagic fish.

In this disinclination to feed I think we have the explanation, firstly, why salmon do not take natural food in fresh water, and, secondly, why they will seize a fly or other lure.

Judging from their feeding habits in the sea, the natural food of salmon in fresh water should be young trout and parr. But trout and parr, assisted by the concealing methods already referred to, are inconspicuous in the water. Now, the salmon, on account of his disinclination to feed, is not on the look-out for food, and his attention is consequently not arrested by these inconspicuous fish, and he leaves them alone. But when a fly, which is conspicuous, is presented to him, he notices the gaudy production, and his attention once arrested, force of habit overcomes his disinclination to feed, and the salmon makes a dash for the fly.

The pink-coloured prawn, which kills so well in clear water, acts in a similar manner.

I have heard it stated, that the fact that the salmon will take a worm is a proof that they feed in fresh water, but we must remember in what form the worm is offered to him. The poacher ties several together in a bunch, or threads them on a large hook. The salmon cannot fail to notice the wriggling of the unwholesome mass, and every now and then he is induced to take the "worm." It is possible that the movements of the fly and the worms, once having arrested the attention of the salmon, remind him of some many limbed crustacean in the sea.

I stated at the beginning of the chapter that attempts to introduce the Atlantic salmon into Australian waters had failed in consequence of the fact that when the fish went to sea they never again returned.

Another attempt is now being made, and recently my friend, Mr. Richmond, of the Surrey Trout Farm and United Fisheries Company, has sent out one million salmon eggs to the Antipodes. Mr. Richmond gave me such an interesting account of how the eggs were collected and dispatched that I will try and reproduce it as far as possible in his own words.

It is no easy task to collect and transmit in a single consignment, one million salmon eggs. The first difficulty is that all the eggs have to be collected about the same time, or those collected at an earlier date would be hatching out before the eggs collected at a later date were ready to start on their long journey.

In our capricious English climate the movements of salmon are extremely uncertain; snow may chill the water and stop the fish travelling up, or droughts may prevent them ascending the rapids. Finally, it may be impossible to net the fish on account of continued floods.

The egg of the salmon is about the size of a large pea; it is translucent and usually of a deep cornelian red. As already described, it has no shell in the ordinary sense of the term, but is covered with a strong, partly elastic membrane, and if thrown upon a hard surface it will bounce like a rubber ball. Salmon eggs possess characteristics which, though they require certain conditions in their transfer, make it possible for them to be sent all over the world.

For twenty-four hours after the egg has been taken from the fish, handling or a slight shock or jar does not injure it, and it can be sent by rail either in or out of water. After twenty-four hours, when the first stage of visible development has begun, the egg becomes exceedingly delicate, and the slightest jar will now kill it. This susceptibility to a jar or shock continues until about one-third of the incubation has been passed through, and the extraordinary thing is that the eggs which would certainly be killed by handling on one day can be handled on the very next with impunity. The expert fish culturist can tell when an egg can be handled without the fear of injuring it by watching the development of the tail of the future fish as seen through the egg membrane.

After this immunity to shock has been arrived at, the egg can be packed for transport.

The time of hatching varies in common with all other fishes' eggs, according to the temperature of the water. The colder the water, the longer is the hatching delayed. It is by taking advantage of this fact that long distance transport is possible. Eggs, which at the temperature of ordinary spring water during winter, viz. 48° Fahrenheit, would hatch in, say, fifty-three days, may be retarded from hatching for one hundred and thirty days by being placed in a cold chamber or packed on ice.

The actual procedure in collecting the eggs is as follows :—

Permission having been obtained from the owners and conservators of a river, men and gear are sent to the spot to be in readiness for the run of fish. The gear consists of nets, retaining cages, spawning apparatus and travelling cans for the eggs, and I might add there is also required patience, endurance, and immunity from being upset by trifles.

The men wait for the flood which will bring the salmon from the sea. At last it comes; for several days the river is a raging torrent, and netting is impossible until the water subsides. During this period of inactivity, the sight of the fish leaping one after another into the various pools, as they ascend the river, may gladden the heart of the collector, and he can start his work with the certainty that some hundreds of fish are gathered together in the field of capture. Should the flood continue, however, there is always the possibility that the fish will run clean through the pools in which the collector is entitled to net. When the river subsides, the water is eagerly scanned. Here and there huge dorsal fins appear above the surface where the broken water rushes over a shallow, or long, red-brown shadows may be seen slowly passing to and fro, where the deeper water swiftly glides along. When satisfied that the fish are there the work of netting is started.

The method of procedure differs with the nature of the water. In comparatively still water a net is drawn through the pools, and fortunate is the collector upon whose field is a shelving pool, free from boulders, tree-roots and stakes. As a rule, a boat follows up the net, in the bows of which stands a man armed with a long pole, carrying at the end of it iron prongs. When the net catches upon an obstruction it is the business of this man to free it as quickly as possible.

In rapid water a different method is employed. Stakes are driven into the bed, and a net stretched across the swiftest part of the river in which a man can stand. A retaining cage is placed near the bank, and landing nets and carrying buckets are in readiness. A carrying bucket is a canvas bag which will hold two or three salmon, head downwards.

A gang of men are now posted some distance up, and walk through the water down to the net. The frightened salmon come swiftly down the current, every now and then revealing their presence by a huge red-brown side or large black fin. As the circle grows smaller the fish charge down-stream and rush head first into the net, and powerful as they are, the force of the water is sufficient to hold them tightly pressed against it. The salmon are now quickly "tailed" by the men in attendance, and placed in the buckets, and from these they are emptied into the retaining box. In this way from ten to twenty fish may be caught in a few minutes.

When the drive is over the fish are again placed in the buckets and hastily transferred to the main retaining tank, which is a structure of considerable dimensions sunk in a suitable place safe from floods and, if possible, under cover.

The salmon are then sorted into males and females and placed in separate tanks. The fishing is then continued until a sufficient stock has been accumulated to justify taking the eggs. The eggs of the female fish are then expressed into spawning dishes, and fertilised by shedding over them the milt, or soft roe, from the male fish. As soon as the eggs have separated and hardened they are packed in cases or jars. The jars are packed in boxes, which contain a non-conducting material such as sawdust, chaff or straw.

There is now less than twenty-four hours left in which to transmit the fertilised eggs to the hatchery, which may be situated some hundreds of miles away.

The spawning is undertaken at a time chosen with reference to the train service, and it may be necessary to begin at midnight in order to leave by an early morning train. The first part of the journey is probably in a cart over hilly roads. In the train the boxes are placed in charge of an attendant. If the journey is at all complicated, all station-masters along the line are advised, and every effort made to secure punctual transmission.

On their arrival at the hatchery, the jars containing the eggs are placed under taps from which the water is allowed to run slowly into them, so that the water in the jars is gradually brought to the temperature of the water in the hatchery. Any sudden change in the temperature of the water containing the eggs would be fatal. When hatching salmon alevins from which the photographs were obtained, as shown in the earlier part of this chapter, I well remember my groom suddenly turning on the cold, town water supply, with the result that out of some two hundred alevins only thirty or forty were saved. After the water has been changed and the eggs washed in the process, the eggs are laid down either in baskets, or on glass grills to undergo the first period of incubation.

While incubation proceeds, the eggs are daily examined, and all the dead eggs picked out with a glass pipette.

In seventeen to thirty days, according to the temperature of the water, the eggs can be moved without fear of injury. The trays are now placed in a shallow basin in a good light, and every egg which does not contain a fish is removed. The remaining eggs are next carefully washed and measured, and are then ready for the packer.

Different forms of packing cases are in use; those used by the United Fisheries Company consist of wooden cases, which have receptacles for ice at the ends and in the lids. Inside the case are arranged numerous shallow trays filled with moss. The moss is covered with sheets of mosquito netting, upon which the eggs are placed. A second sheet of netting is then put over the eggs and on the top of this another layer of moss.

One million salmon eggs weigh just under four hundredweight, and require twenty cases to hold them. The total weight of the consignment is about one ton and a half.

On board ship, the cases are placed in a specially ventilated cool chamber, with an abundant supply of ice.

As the eggs near their destination the temperature in the cool chamber is allowed to rise gradually, and after being landed, the cases are dispatched as rapidly as possible to the hatchery.

The earlier eggs may hatch within a day or two, or even within an hour of being laid down in the warm water, while others may not hatch for a fortnight or more.

It is to be hoped that this consignment of eggs sent out by Mr. Richmond may be the means of establishing the Atlantic salmon in the Antipodes.

As a sporting fish, the sea-trout does not take second place even to the salmon, and no man can wish for a better day's fishing than when three- or four-pounders are running and taking the fly. Unfortunately, many a fine sea-trout is killed on a seventeen-foot salmon rod, which allows the fish no chance to show his fighting powers.

Except to those who are constantly handling salmon and sea-trout, it is not always easy to distinguish at a glance one from the other, and more than once, notices have appeared in the Press such as "salmon caught in the Thames," or in some other waters equally uncongenial to the King of Fishes, the fish caught really being a sea-trout.

It does not, however, need an expert to distinguish between these two fish, for there is an infallible sign by which a small salmon or grilse can be distinguished from a sea-trout.

In the salmon there are ten to twelve scales present along an oblique line running forward from the root of the adipose fin to the lateral line; in the sea-trout the scales number fourteen.

The sea-trout appears in our country under various names, for example, the salmon trout, the white trout, the peal, the sewin and the bull trout. Like salmon, sea-trout spawn in fresh water and migrate to sea. But they differ considerably from the salmon in their habits, the most important point of difference, so far as the fisherman is concerned, being the fact that they feed in fresh water. A sea-trout starts life as an alevin, fry and parr, and then becomes a yellow fin, which corresponds to the smolt in the salmon. The yellow fin goes to sea and returns after three or four months weighing about a quarter of a pound, and is then known as a finnock, herling, or whitling. Coming back into fresh water about June, finnock feed freely and by the end of the year may have increased to a pound in weight.

The finnock go down to the sea during the winter without spawning, and return next year as sea-trout. These fish weigh two to three pounds, according to the length of their stay in salt water; they then spawn, and may come back next time weighing five or six pounds.

Now, though the salmon can be distinguished from the sea-trout, and from the brown trout that has acquired migratory habits, it is a very different matter when one has to distinguish the sea-trout from a sea-going brown trout.

The sea-trout and the brown trout have each fourteen scales along the oblique line referred to, and in order to distinguish one from the other the naturalist has to fall back on the arrangement of teeth and certain appendages inside the digestive tract.

The salmon, the sea-trout and the brown trout all have teeth on the hard palate, along the middle line. In the salmon these teeth are very few in number, but in the brown trout they are very numerous, and in the sea-trout the number of teeth are somewhere between the two.

Both the teeth and appendages are liable to a great variation, and I am confident that many a brown trout that has gone to sea, has been called a sea-trout on its return journey.

The complete change in the appearance of the brown trout which causes him to be mistaken for a silvery sea-trout, is accounted for by the food supply and change of environment.

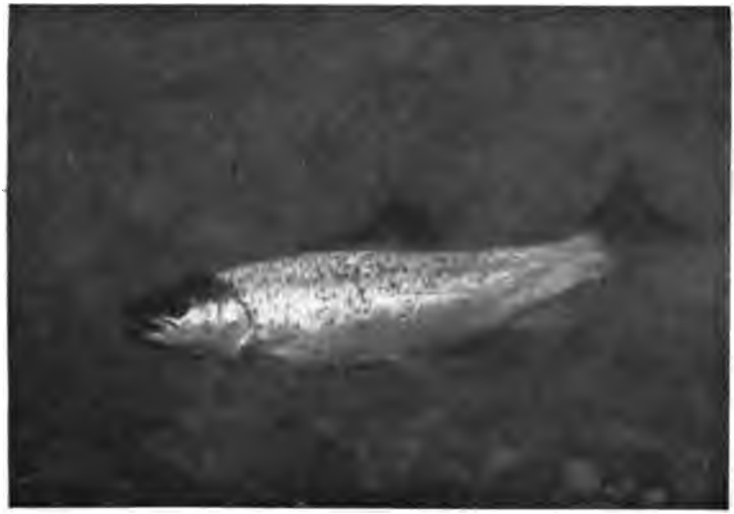
Changes in colour and markings are generally attributed to environment. A trout, for example, living in a deep hole of a brook, with a muddy bottom, is found to lose his bright spots, and to become of a dull colour, whereas the same fish living in a rapidly flowing stream with a gravelly bottom becomes bright in colour, and covered with numerous well-marked spots.

Though environment undoubtedly has a material effect upon the coloration of the trout, food is an equally important factor in bringing about colour changes, and both colour changes and silvery iridescence may result from food and food alone.

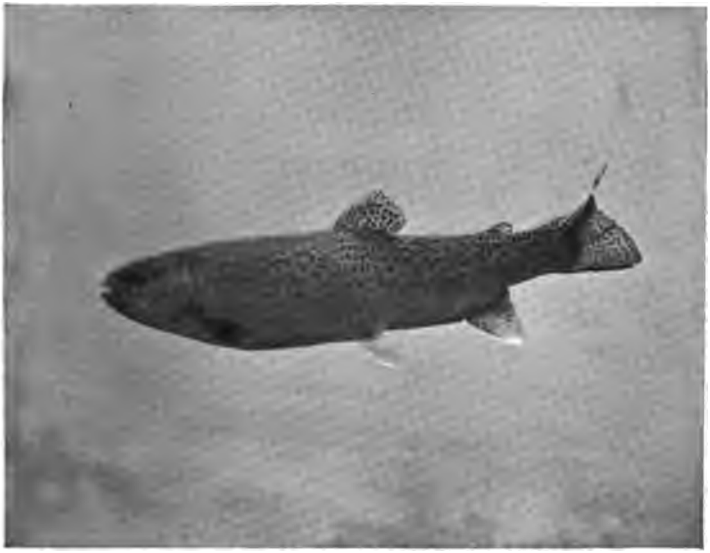
As an illustration of this point, I would quote from the experience of my friend, Mr. Richmond.

On his fish farm at Shottermill are two similar ponds about one hundred and twenty yards apart. These were supplied from the same water source, but the food in them was of a totally different character. The upper pond abounded in molluscæ, but the food in the lower pond consisted almost entirely of daphnia and cyclops. Both these ponds were stocked at the same time with trout similar in appearance. Very soon, however, the fish in the upper pond became dark in colour with intense red spots and yellow underparts, while those in the lower pond assumed a silvery appearance shot with a pale pink hue.

The silvery appearance of the trout in the second pond, was due to deposits of light-reflecting spicules, known as iridocytes on the scales of the fish. When



SEA TROUT, PHOTOGRAPHED BY FRONT LIGHT, SHOWING ITS SILVERY BODY.



RAINBOW TROUT. THE SILVERY BODY REFLECTING THE COLOUR OF THE WATER.

Photographed in the Pond.

these iridocytes are present as a continuous reflecting surface in the deep layers of the skin, the light reflected by this surface is seen through the skin, and gives the fish a dull white appearance, but when, in addition, iridocytes are present outside the scales, as I have already explained, they act like so many prisms and, breaking up the light reflected from the deep reflecting surface, give the fish its silvery iridescence. These iridocytes consist of guanin, and guanin is derived from rich animal food such as the cyclops and daphnia in the second pond. The peculiar pink shade that these fish had acquired was due to the partial masking of the normal colour cells in the trout by the excessive number of iridocytes which had been formed on the scales of the fish.

When the brown trout acquires the habit of going to sea, he has an opportunity of feeding on abundance of guanin-forming food, and acquires a similar silvery appearance. In passing, I would draw attention to the fact that this alteration in the appearance of the trout in the sea helps to protect him by making him inconspicuous, for though the dark colour and the numerous brilliant spots make him inconspicuous on the pebbly bottom of a stream, they would attract attention in the sea. The increase of the iridocytes in his skin make him reflect his surroundings in a similar manner to the dace which has been already described.

Further, though the bright spots of the brown trout all disappear in the sea, he is not altogether devoid of markings, for on his sides, back, and head are seen numerous black dots and cross markings. If the trout were merely silvery all over, he would only be completely inconspicuous when the background against which he was seen was of the same uniform shade as the water around, but the trout in the sea moves among stones, weeds and the numerous forms of animal and vegetable life floating in the sea. The silvery sides reflect the tone of the surrounding water, and the black dots just sufficiently break up the uniformly shaded body of the fish to give it a mottled appearance as he rapidly swims about. I have noticed both rainbows and Loch Levens swimming in the pond amongst roach and dace, and there is no doubt that the rainbow and the Loch Leven, with their black spots and marks, are less conspicuous than the roach and dace, except when seen against a perfectly uniformly shaded background, which is a condition seldom, if ever, met with in the sea.

Though I would not say that the sea-trout is a brown trout that has gone to sea, it is certainly more closely related to the trout than to the salmon, and for this reason I consider the name of sea-trout more applicable to this fish than salmon trout.

Next, let us turn our attention to the bull trout. One is frequently asked, what is a bull trout ? A bull trout would appear to be nothing but a large sea-trout. At the same time, I am convinced that many a brown trout that has acquired the habit of going to sea, on its return to fresh water has been described as a bull trout.

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RAINBOW TROUT AS SEEN IN THE POND.

Reference has already been made to the extraordinary change that takes place in brown trout in Tasmania and New Zealand. These fish at home would be called bull trout. Further, Sir Herbert Maxwell quotes in his book on "British Freshwater Fishes" from so high an authority as Sir Gibson Maitland, that if the young of bull, hatched from bull trout eggs, are prevented from going to sea, they retain the habits and character of ordinary brown trout.

Of our fresh-water salmonoids, there is little doubt that such fish as the Great Lake trout (*Salmo ferox*), the Loch Leven, and the gillaroo and others, are merely varieties of the common brown trout due to perverted feeding habits and special environment.

The Great Lake trout is a cannibal pure and simple, and the strongest evidence that this particular trout is merely a perverted brown trout is that the young of this fish as a Great Lake trout do not exist. If the reader has any doubt of the Loch Leven being a brown trout in disguise, let him import some of this wild sporting fish, and turn them into a pond or stream where no other trout exist. Removed from the food and deep waters of Loch Leven, in a few months' time these imported fish will be difficult to distinguish from the common brown trout.

The gillaroo of Ireland is distinguished by his large brilliant red spots, his golden colour, and the immensely thickened lining of the stomach wall. The coloration and the thickening of the stomach wall can be accounted for by the character of the food in Loughs Melvin and Mask, where the gillaroo is to be found. This food mainly consists of bivalves and molluscs, and as we have already seen the trout acquire brilliant red spots on a mollusc diet. It is stated that the stomach of the gillaroo is thickened in order to crack the shells of his indigestible food.

The rainbow is a fish with which most people are now familiar, and is a native of the Pacific Coast of America. Unlike the salmon and sea-trout at home, the rainbow spawns in the spring instead of in the autumn, and at the moment of writing—in the month of May—they are spawning in the observation pond, as will be described later.

The char is a near relative of the trout, and in our country is found mainly in the Lake District and in the Lake of Windermere in particular, though chars are also found in certain deep lakes in Scotland and Ireland. I have tried to photograph this fish, but it is impossible to do justice to its brilliant hues except on a colour plate.

Char keep to deep water, except in the autumn, when they come on to the shallow banks or ascend streams in order to spawn. At the breeding season the char as seen in Windermere is a very brilliant fish. The back, right down to the lateral line, is of a dark green shade, and this gradually tones off into a rich crimson colour on the under-parts, and on the green sides of the fish are numerous well-marked red spots. The fins on the back and the tail fin are dark green, while the other fins are red, lined round with a clear white border.

Char are a gregarious fish and swim in shoals, and in the autumn, when they come on to the shallows to spawn, are netted in immense quantities to appear on the table as "potted char."

The brook trout of America (*Salvelinus fontinalis*) is a char, a splendid sporting fish that takes the place of the brown trout in our country. Attempts have been made to introduce the brook trout into England, with a certain amount of success in a few deep lakes and ponds.

At the beginning of this chapter, I briefly referred to the white fishes of America, which are an extremely interesting group of the salmon family. The artificial cultivation of these fishes is probably more extensive than of any other fishes in the world.

When watching the members of the salmon family from above the water, most of us will have appreciated the fact that the male fish at the breeding season becomes excessively pugnacious, but I never realised to what extent this pugnacity was developed until I observed the mating of rainbow trout in the observation pond.

Two male and four female rainbows were turned into this pond amongst various other fishes. The rainbows came a long journey by train, but within two days of being turned into the pond the males were fighting furiously. After the first few battles one of the fish was master of the situation, and the other recognising his inferiority, retired into a dark corner, and whenever he dared to come out of hiding, he was immediately pursued and driven back by the victorious fish.

For two or three weeks the fish that was master of the situation was at peace with all the female rainbows in the pond, but later on he attached himself to one in particular, and made her take up her quarters in the pond by a large stone at one side of the glass. The male was never more than a foot or two distant from this fish, except when chasing and viciously biting the other fish in the pond.

If the rainbow to which he had attached himself moved from her quarters, he immediately went in pursuit and drove her back.

In consequence of being disturbed by my fox terrier (who is an ardent fisherman) these two fish moved off near to a ledge of rock in a different part of the pond, and here I had the opportunity of watching them spawn. The bottom of the pond was covered with about six inches of gravel and the ease with which the female fish fanned away the large pebbles was marvellous.

At first the concrete bottom of the pond was laid bare over an area the size of a soup plate, then as she advanced over the ground during the process of spawning, this bare patch was again covered up, and a new patch appeared nearer the edge of the pond. The total area of gravel turned over by the fish covered a space four feet square.

Trout are supposed not to feed when they are spawning, but rainbow possibly differ from other trout in this respect, for when these fish were resting during their spawning operations, they were always ready to feed, and on one occasion I threw in fifty meal-worms one after another, not one of which was allowed to reach the bottom, and the last was taken as keenly as the first.

During the spawning, no fish were permitted to come near the redd, but in addition to driving them off, the male rainbow constantly made excursions over the pond with the deliberate intention of biting and chasing the other fish, and there was hardly a roach in the pond that had not been marked by him.

The observation of various trouts as seen from below the surface of the water also enables one to appreciate their agility, and the perfect control that they have over their movements. When a trout lying near the bottom rises to a fly on the surface, he comes like a flash of lightning, and so rapid are his movements that even with an exposure of $\frac{1}{250}$ of a second, it is impossible to get more than a blurred image. But should a trout take up a position a foot or so under the surface of the water, it is possible to watch closely his movements as he rises to a fly, and also obtain fair photographs with a quick exposure.

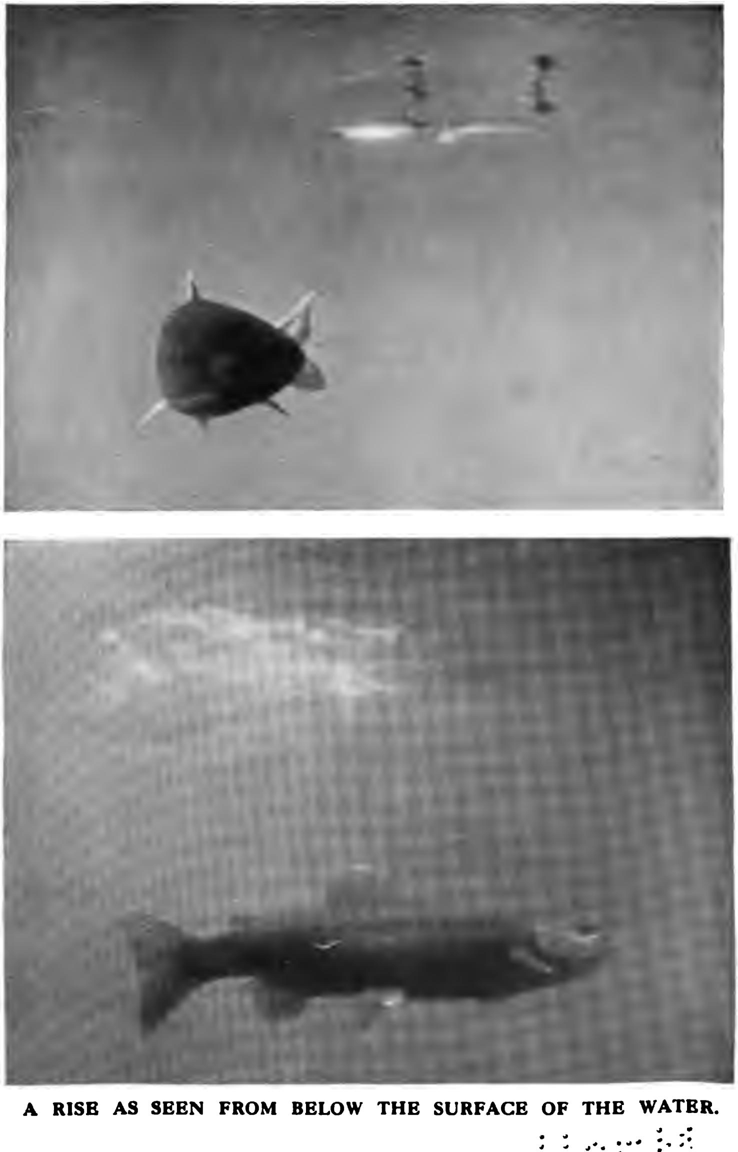
When the fly is almost above him, the trout suddenly comes up at an angle of about forty-five degrees, and sucks it down, and then as he again descends, he breaks the surface of the water with his tail. The trout is now about two feet in front of his original position, but he does not remain here, for continuing his progress he swings round, almost invariably the same way each time, and comes to rest within an inch or two of the place from which he started.

The whole manœuvre is an uninterrupted glide, and it is difficult to realise the speed at which the trout is moving until an attempt is made to photograph a rise as seen from below the surface of the water. The two illustrations shown were taken on a bright day, and the photographic working details were :—

Exposure, $\frac{1}{250}$ of a second; lens aperture, *f* 4; plate speed, H and D 400; distance of lens from the fish about seven feet, and yet the fish going across shows considerable movement. In explanation of the two photographs: the top one shows the trout having completed the rise, and the fish is seen end on in the act of coming round. The bottom illustration shows him going across. He then swung round once again, and was in position for the next fly.

It may seem extraordinary that a trout will come back time after time to the same place in the water when apparently that place is no better than a foot or two higher up, but every dry fly fisherman will confirm the fact that he does so.

The power of controlling their movements is well seen when a worm is thrown into the water, and two fish rush at it from different parts of the pond. Arriving at the food about the same time a collision seems inevitable, but I have never seen trout actually strike



A RISE AS SEEN FROM BELOW THE SURFACE OF THE WATER.

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each other, for at the last moment the fish that is only a few inches farther off the food suddenly slips aside and then turns round in his own length, and not infrequently ends by getting the worm. This is in consequence of the fact that when a trout seizes a worm, or other wriggling form of food, he gives it a bite, and then spits it out to swallow it again. The fish that missed the bait is aware of this fact, and suddenly turning round frequently snaps up the worm before the fish that spat it out is able to seize it again. Unless trout are exceedingly hungry, I do not believe they ever swallow a worm until they have killed it. They may bite it and spit it out two or three times successively as already described, or taking it into their mouths they masticate it well for several minutes before they swallow it.

CHAPTER VI

THE CARPS

THE majority of freshwater fishes found in the northern climes of Europe, Asia and America belong to the carp family.

In our islands we find the carp itself, the tench, the bream, and all the "white fishes," such as the roach, rudd, chubb, and dace.

The carp vary immensely in size and external appearance. The huge mahaseer which has given sport to many an Anglo-Indian in the rivers of Northern India is a carp, so also is the homely minnow.

The word "carp," however, usually conveys to our minds a big bronze-coloured fish covered with large scales, and possessing a leathery mouth which can be shot out like a tube.

When writing about the carp, it is usual to start with historical allusions to his antiquity, always bringing in Fontainebleau, Louis XIV., the Prince of Condé, and the monks of old. The writer then goes on to describe how to fish for him with raspberries, cherries, peas and plums, pudding, cake, and paste, the last prepared with or without worm juice, according to the fancy of the angler and the carp. But I propose to deal with him first as a sporting fish, and then to write a few words on his early life history.

I have fished for salmon on the rushing Spey and in Highland lochs, for sea-trout in Ireland and in the Hebrides, for brown trout in various waters, from a peaty burn on a wild Scotch moor to a crystal stream amongst Swiss mountains, and I can say, without fear of contradiction, that there is no fish that will put up a better fight than a big carp.

Some years ago I had an opportunity of fishing in a pond, which by report held some monster carp; not a fish under ten pounds and most of them twenties and thirties!

All arrangements had been made for days before, when a friend and I started out at three a.m. on a damp September morning, full of hope. The water was seven miles off, and when we were about two miles from our destination, we simultaneously remembered that the other had forgotten the paste. Of boiled potatoes, lob worms, brandlings, cheese, we had plenty, but what was the good of going carp fishing without paste?

Fortunately, we passed a farm-house and saw a light burning, and blessed the people for being such early risers. We found, however, that the previous day had been the farmer's birthday, and he and a few friends were celebrating the occasion, and had not yet gone to bed. We struck the farmer in a most affable mood, and made paste flavoured both with honey and cheese.

I believe he would have given us the grandfather clock to offer to the carp had we asked for it!

By 4.30 we were fishing. I took off my boots, and persuaded my friend to do likewise, for in order to catch carp it is essential that no vibration be caused by walking about on the bank. Talking, too, is not permitted.

I baited my hook with a large lob worm, and my friend used sweetened paste. The first hour passed quickly, the second hour slowly, the third hour very slowly, but the carp were constantly working all round our bait, and so we decided to give the spot another hour before shifting our ground. At last my float was seen to move slowly towards a patch of water-lilies, but without going under, and I thought a small perch or roach was playing with the big worm. Suddenly, under went the float, and after it had gone two or three yards I struck. Without a moment's warning, thirty yards of line were taken right off the reel towards the centre of the pond. Then followed twenty minutes of real sport as I played him as hard as my light tackle would permit. Time after time I got him almost to the bank, but as soon as he saw my friend with the net off he rushed again, now boring deep into the mud, now skimming along the surface, often getting perilously near the weeds on the other side. In the end, he managed to get amongst the reeds. All now seemed over, when my friend, grasping the situation, waded into the pond up to his knees in mud, and up to his waist in water, and quickly got the net under the now almost played-out carp. This fish just turned the scale at nine pounds. Imagine hooking a twenty pounder, such as you read of in the old books!

Wet as we were, for I had to assist my friend out of the mud, we fished for another hour—a childish proceeding, for we might have known that disturbing the water as we had done would put the other fish entirely off their feed. You can never expect to catch more than one big carp in the same spot on the same day.

When the water in which you intend to fish is sufficiently large, the best plan is to ground-bait two or three holes, and when lucky enough to catch a carp in one place, move straight off to another.

One often hears and reads of cute ways of outwitting fish, but somewhere I read of a most ingenious method of reaching inaccessible carp. The fish were right out in the water, and were far too shy to permit of a punt being brought anywhere near them. The angler, choosing a suitable breeze, threaded his gut through a large leaf, which acted both as a float and a sail, and carried his bait out to the carp, resulting in the capture of a fine fish.

Carp thrive in deep still waters overgrown with pond weed and other vegetation. From the months of October to March not a fish is to be seen, for they are lying buried in the mud, and this habit of burying themselves for warmth during the winter months is shared with many other members of the carp family. In April they again begin to show themselves, and in May and June they spawn.

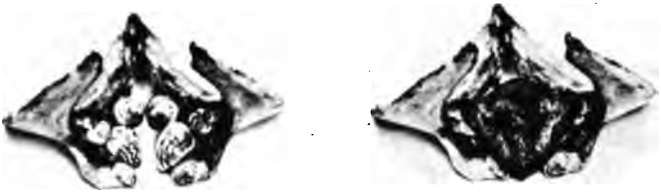
If one has never seen carp spawning, it is difficult to imagine that these clumsy-looking fish could suddenly become so active. Rushing about, they chase each other, churning the surface into froth with their violent splashing, and frequently jumping a foot or more out of the water. When the spawning actually commences, the female fish deposits her eggs on the vegetation at the side of the pond, and as soon as she leaves, the male, dashing forward, fertilises these eggs by shedding his milt, or soft roe, over them.

The eggs are deposited at irregular intervals, and I see from my notes on carp that I have taken a fish full of spawn as late as September 9th. This bears out the statement that the eggs of one season may be retained until the following year.

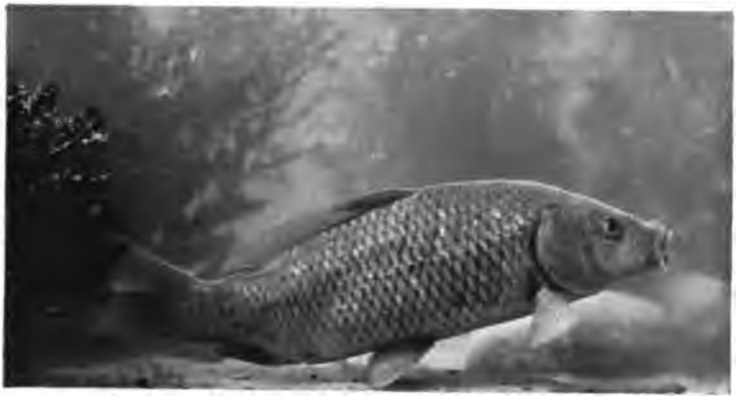
Carp feed on larvæ and insects, and young shoots of aquatic vegetation, picking up most of their food off the bottom.

As every angler knows, carp, tench and other fish, when feeding on the bottom, disturb the dead leaves, and bubbles of gas rise to the surface. I have met fishermen who profess to tell by the way these bubbles come up what sort of a fish is on the feed, and on more occasions than one I have found their statements to be quite correct.

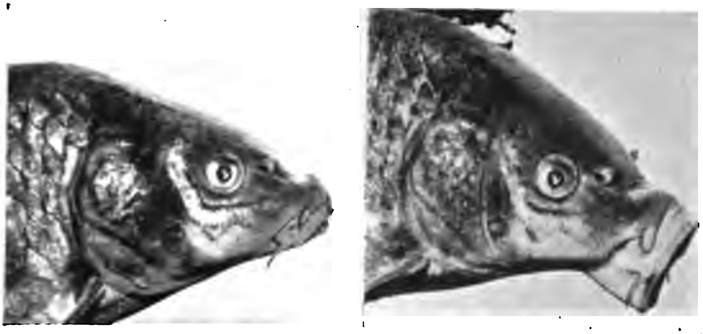
When a carp detects food, either by touch or smell, he shoots out his thick leathery lips, and the food is



THROAT TEETH OF THE CARP.



THE CARP (*Cyprinus carpio*).



MOUTH OF THE CARP.

carried up by the eddy as the water enters his mouth. This food is thoroughly ground into a pulp by the teeth in the throat, any larger pieces of food which pass into the stomach being returned to the throat to be masticated.

If you take any of the carp family and slip your finger behind the gill cover, you will feel several arches on either side which carry the gills, and attached to the last of these arches are the throat teeth.

In the carp the throat teeth have broad grinding surfaces, which work against the pad of gristle in the roof of the throat. In the chubb these teeth are pointed, and when they are made to meet the teeth on the other side, this fish is able to cut a minnow clean in two.

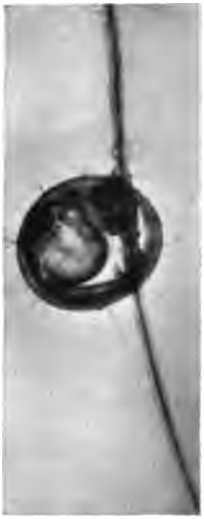
The grinding teeth of the carp shown in the illustration have an interesting history. In 1902, Ipswich was visited by a terrific storm; the water rushing down the paths in the park, cut great gulleys six feet deep, and a torrent of mud and sand swept through the fish ponds; from these ponds the water went through the houses at the bottom of the park, and carried fish right into the town. The carp from which these photographs were obtained weighed seven pounds, and was found among the branches of a tree in a private garden. Among other fish a four-pound eel was taken in the cellar of a house. Thousands of fish died, their gills being absolutely clogged with fine sand; many of the bigger fish might have been saved if the grit had been gently washed away, but the whole town had suffered, and had more to think about than the fish in their park.

There is a common, but erroneous, impression that carp feed on mud. This idea must have arisen from the black, slimy contents found in the stomach and intestines of this fish, in consequence of the food being thoroughly ground into a pulp.

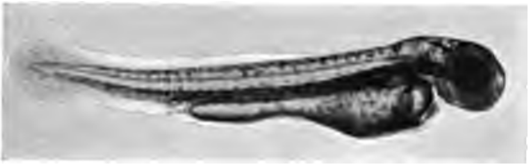
In warm weather carp are to be seen basking on the surface of the water. A cold day comes, and there is not a sign of a fish. When standing by a pond on a summer's evening one often hears sounds like deep-toned slobbery kisses. These do not emanate from a rustic swain and his wench, but are due to carp and tench just breaking the surface of the water with their leathery mouths as they gulp down air.

To revert to the fertilised egg of the carp. In a week or ten days' time the larval fish hatches, coming out tail first. This carp larva is not at all like a fish, and to the naked eye he appears as a fine dark line about a quarter of an inch in length, with two black dots at one end. This line is due to a row of numerous dark colour cells running the whole length of the little fish, the rest of him being too transparent to be seen. The two dots at the end are his little eyes. As in other larval fishes the primitive fin runs right round the body, but the yolk sac is peculiar in being of an amber colour. The minute structure of this larval carp is seen in the micro-photograph shown opposite p. 102.

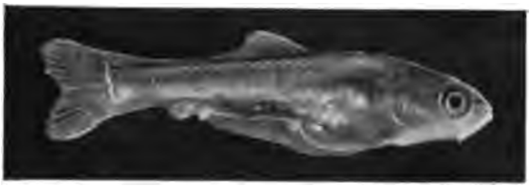
One of the carp with which we are most familiar



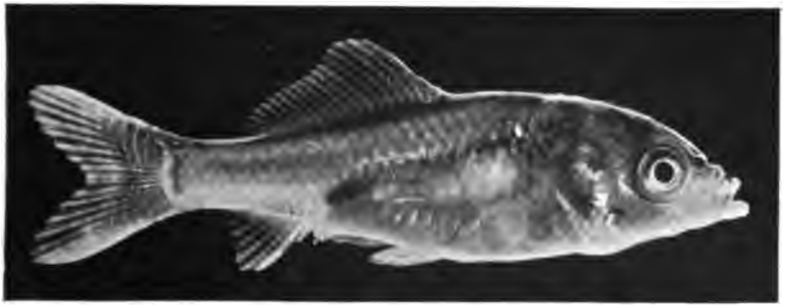
Ready to hatch.



Just hatched.



Six weeks old.



Ten weeks old.

THE GOLD FISH (*magnified*).

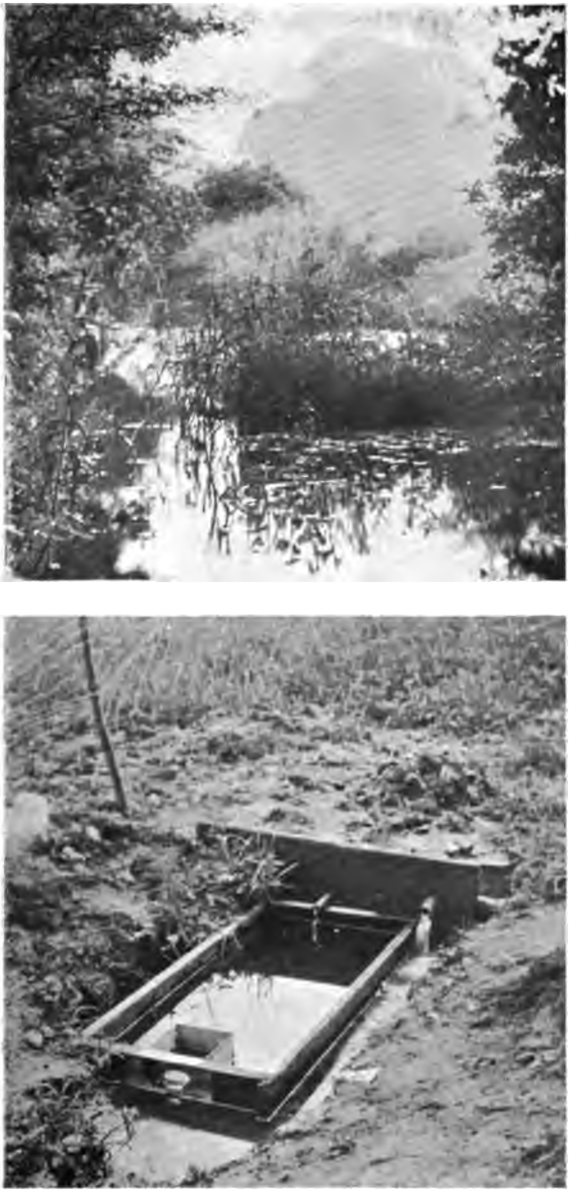
is the goldfish. It is quite possible for anyone who has a pond in his garden to get this fish to breed, and to watch for himself its early life history. In May and June search the leaves and stems of the plants in the pond for small, round greenish-yellow semi-transparent eggs, about the size of rape seed, gather the leaves to which these are attached, and place them in a floating cage in which you will be able to watch the young fish hatch and grow. The simplest way to make a floating cage is to take a large biscuit tin, cut openings in each of the four sides, leaving the bottom intact, and solder over these openings fine wire gauze, twenty strands to the inch. Then float this cage supported in a wooden frame, so that there is a couple of inches of it above the surface of the water. In this manner the young fish get their natural food as it comes through the fine gauze, and at the same time they are protected from their enemies. I have been able to rear several of the carps in this manner, and in one case only did this apparatus fail. In a floating cage were several young bream, and when these were examined after an interval of some time nearly all the young fish were killed, and the cage was swarming with water-boatmen. These had evidently got in through the gauze netting while they were quite small, or had been carried in as eggs, and had rapidly grown upon the sumptuous fare they found inside the cage.

At six weeks old the primitive fin round the body of the goldfish disappears, and the various fins become separate and distinct. At three months old he is very much the same shape that he will be in after-life, except that he is not so thick in the body. At this age the goldfish is a beautiful little object, and can be transferred from the cage into a glass vessel to be watched. The best way to pick out larval fishes is with a glass pipette.

All the early stages of the members of the carp family are very similar, so far as I have at present examined them, and these include the carp, the bream, the roach, the rudd and the minnow, but there is sufficient variation to enable one to be distinguished from the other with the aid of the microscope.

I used to wonder how it was that the early life histories of our pond fishes had never been described, until I started to work out that of the roach for myself.

The first year I tried in an aquarium which had been prepared months beforehand and contained abundance of microscopic food. The eggs hatched, but all the larvæ were dead within a day or two. Next time I arranged six large tubs in a row, connecting them together with three-inch lead pipe, and again bred in these all the minute forms of pond life. This time the roach eggs were placed in an open wooden tank and the water from the tubs was made to circulate through it. Again the eggs were hatched, and again in a day or two all the larvæ were dead. The third attempt resulted in complete success, for, in addition to using floating



WATER SUPPLY AND BOX USED FOR REARING ROACH.

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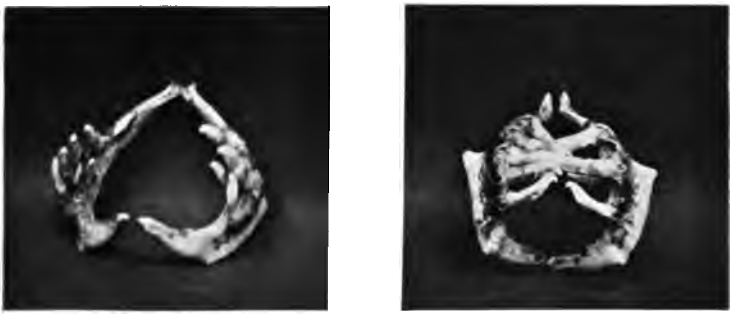
cages, I sunk a large box in the earth and supplied it with a constant stream of water from a natural source.

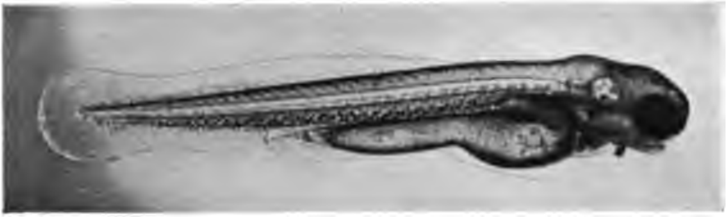
As there are several life histories still to be worked out, I will describe this sunk box method in some detail in the hope that it may be useful to others who feel inclined to investigate for themselves. Selecting a ditch which remained at a fairly constant level all the year round, I led the water from it in a 2-inch pipe to a box sunk in the ground. At the head of the box by means of a board and clay puddle, I held up the water a few inches. The board was pierced by two lead pipes, one a half-inch in diameter, which allowed the water to go into the box; the other, a two-inch pipe, pierced the board at a higher level, and to one side, and carried off the excess. By this means the water always ran at full bore through the half-inch pipe. The overflow from the box had to be guarded by very fine gauze, twenty strands to the inch, in order to prevent the roach larvæ escaping. At first I found the scum on the surface of the water blocked up this fine gauze, and the water flooded over the side of the box. To overcome this I nailed a square tin sieve on to the end of the tank, so that two inches of the sides of the sieve were above, and two inches were below the surface of the water. An overflow hole was cut through the end of the tank and through the side of the sieve in contact with it. The scum now gathered on the solid sides of the sieve and on the end of the tank, and the water welling up through the gauze which formed the bottom of the sieve escaped through the overflow hole. I show an illustration of the ditch from which the food-laden water was gathered, and the box below it. Owing to the kindness of my friend, Mr. Mower, who visited these fish morning and evening, and cleared the box and pipes of scum, this simple apparatus never failed the whole summer.

As the water in the box was only nine inches deep the eggs, larvæ, and young fish could easily be watched, and specimens gathered when required for photographic purposes.

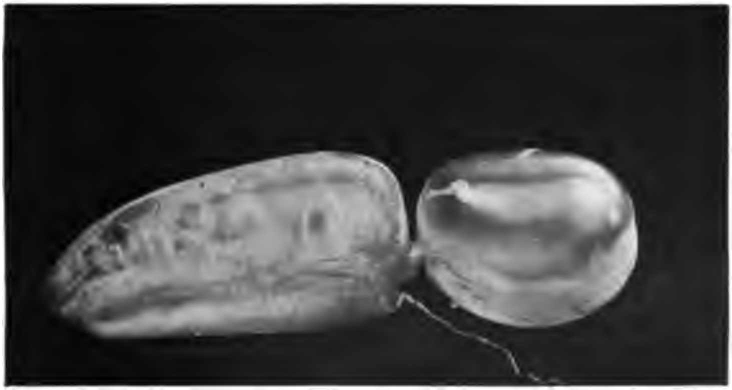
Without going into minute details, which would be out of place in a book of this kind, I will describe the early history of the roach during the first year of its life, and this may be taken as an example of the carp in our ponds and rivers. Before doing so, however, it is necessary to say a few words about the gas bladder of fishes, for the habits of the roach before and after this appears, are entirely different. Almost all bony fishes possess a bladder, which runs along the body just under the backbone. This bladder though commonly known as an air bladder, does not contain air, but mainly oxygen gas, and its presence in the body of the fish makes it, bulk for bulk, the same weight as water. Thus the fish floats, and having no weight to support, swims with the minimum of exertion. A fish is also able to diminish or increase the amount of gases in this bladder so as to float in different depths of water. The gas bladder of a carp has a constriction in the middle as shown in the illustration on the opposite page.



THROAT TEETH OF CHUB.



CARP (*Cyprinus carpio*) HATCHED SIX HOURS.



SWIM-BLADDER OF CRUCIAN CARP.

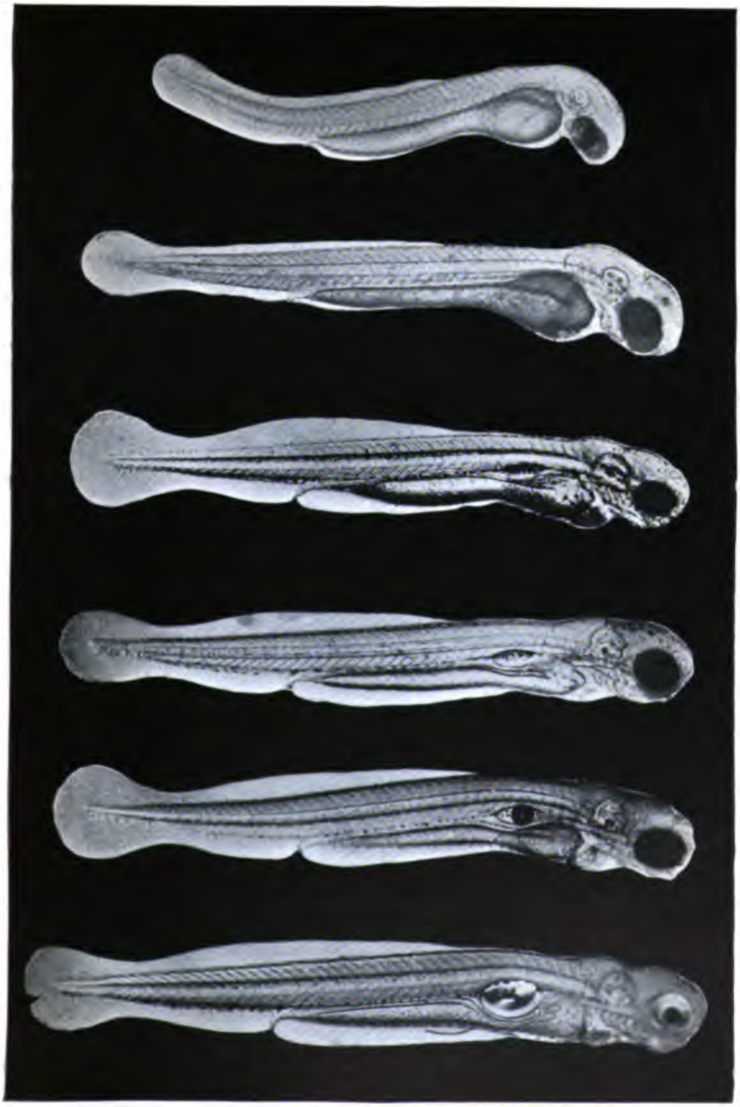
To return to the roach. Roach eggs take seven to fourteen days to hatch with the water at a temperature of 59° F. If the eggs are attached to the vegetation near the surface, the extra light and warmth hurries on the hatching. If they are placed deeper in the water hatching is somewhat delayed.

When the roach larva escapes, he is about a quarter of an inch in length, and has an arched back and turned-up tail. Exhausted with the exertions of struggling out of the egg, he sinks to the bottom, but in an hour or two he has gained sufficient strength to swim, and he comes up to the surface with a circular wriggling movement. This peculiar method of progression is due to the tail having an upward tilt.

The larva at this stage has no gas bladder, and so if he stops swimming he immediately sinks, but if he reaches the surface and still continues to swim, he twirls round and round, making rings on the water. When roach are hatching in large numbers on a warm still day, these rings are visible all along the banks of pond or river. In six to twelve hours the larval roach has become quite straight, and now swims about rather more, but he still has no gas bladder, and has to swim all the time, or sink. When, however, he touches anything, or comes up to the surface of the water, he now appears to be held up by what I thought to be capillary attraction, though since it has been suggested to me that he is really held up by the mucus on his body. At this stage many of the larvæ rest at night in a perfectly perpendicular position with their heads in contact with the surface of the water.

During this time, just above the centre of the yolk sac, a number of dark-coloured cells have massed together in a space where the gas bladder is going to appear. These dark cells then draw upwards towards the top of this space, leaving the rest of it clear. Suddenly, in this space will appear a minute gas bubble caused by the action of these cells on the blood of the fish, which rapidly increasing in size, gives the fish the appearance of having a pearl in his body. The larva now has a primitive gas bladder filled with a bubble of oxygen, and immediately his whole mode of life alters. He now never goes down to the bottom, but floats in the water from six inches to a foot below the surface. The manner of progression also changes, and the young fish advances with a peculiar jerky movement like a water flea, alternately stopping and shooting forward, and at night he rests floating in a horizontal position. All these changes occur in two to three days.

The larvæ henceforward, like the parent fish, swim in shoals, keeping in the sunlight, and carefully avoiding dark corners. The perception of these little creatures is extraordinary, and once the gas bladder has appeared they are extremely difficult to catch, persistently dodging the end of the pipette used for picking them out of the water. Even when the pipette is held quite still in the hope that one will come sufficiently near to be sucked up, they give it a wide berth.



FIRST TWO DAYS IN THE LIFE OF A ROACH (*Leuciscus rutilus*).

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For the first eight or nine days the young roach grows exclusively at the expense of the food in the yolk sac, but about the ninth day the mouth becomes open, and he commences to feed, the food in the yolk sac now being practically exhausted.

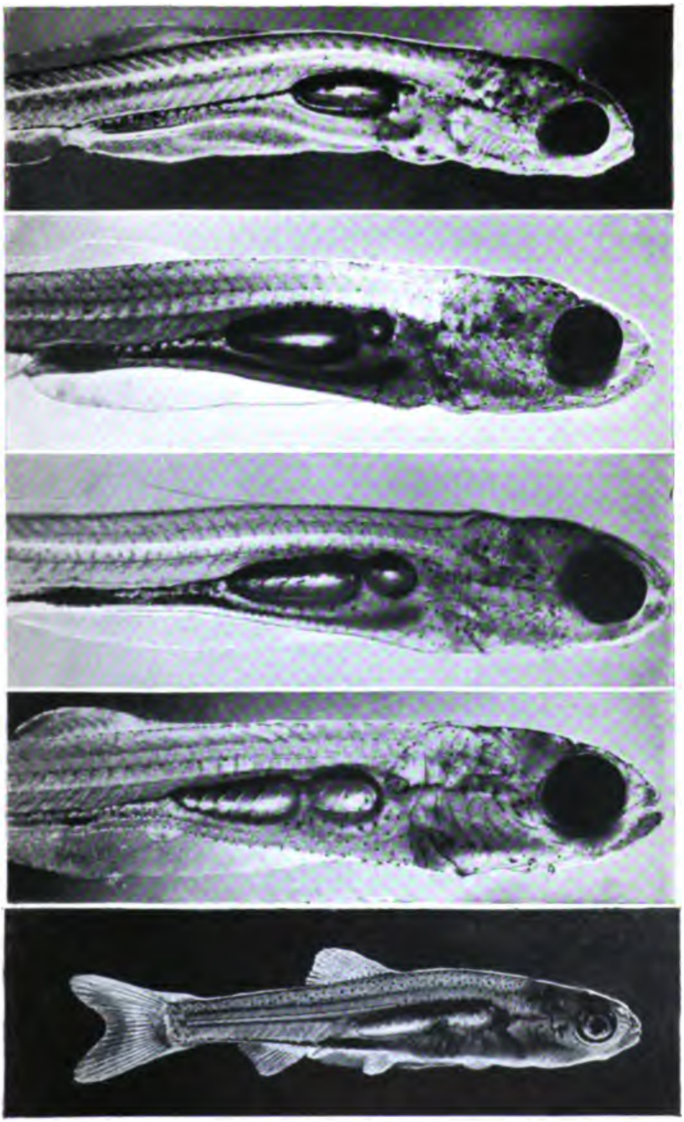
At three weeks old the larva has grown to more than twice the length he was when hatched, and the gas bladder is now sausage shaped.

At the end of three weeks a bud appears at the right-hand top corner of the single-chambered gas bladder. This bud rapidly increases in size, and within a week has formed the front half of the constricted gas bladder of the roach. A glance at the photographs facing p. 106 will illustrate this point better than further description.

At six weeks the roach is almost a perfect fish, and only the rudiments of the primitive fin remain. Plenty of food is now all that he requires, and until the autumn the larvæ grow rapidly. With the cold weather, food becomes scarce, the digestive juices in the stomach cease to flow, and the growth of the fish is arrested until the weather again becomes warm. At the end of the first year, most roach fry are about an inch and a half in length, though they may have grown to twice this size under exceptionally favourable circumstances.

The carp is not a fish of much importance in our country, but in Germany its cultivation is systematically undertaken. Suitable carp food is bred in ponds, liberally supplied with sewage. Into these ponds the carp are herded like a flock of sheep, and are moved into the next pond as soon as the food supply in the first is finished. Enormous quantities are both eaten and sent away. The orthodox method of preparing this fish for the table is to have it cooked in beer.

I tried carp cooked in this way, and came to the conclusion that the beer could not have been very good.



GROWTH OF SWIM-BLADDER: ROACH.

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CHAPTER VII

MARINE FOOD FISHES

THOUGH most of us are familiar with the cod, the herring, the mackerel, the plaice and the sole, and many other sea fishes which are used as food, yet it is exceptional to meet anyone who knows much about their lives and habits in the sea. During the last fifty years, however, the perseverance of the marine biologist has pieced together the life histories of our food fishes, and considerable knowledge has been gained of their habits.

The first discovery of importance in tracing these life histories was made by the Norwegian naturalist, Sars. Sars had been sent by his Government to report on the cod fisheries off the Lofoten Islands. The fishermen had informed him that the roe of the cod floated in the sea, and at times was so abundant as to make the water thick. This statement was thought to be a fisherman's yarn, but, as is so often the case, the fishermen were correct.

The usual method of collecting marine life near the surface is by means of a tow net. The tow net in its simplest form, consists of an iron hoop, to which is attached a cone-shaped muslin bag. When in use the net is dragged through the water behind a boat.

Using a tow net, Sars found in his hauls, among the hundreds of other forms of minute marine life, a few perfectly transparent spherical globules, about one-twentieth of an inch in diameter. The microscope showed these globules to be fish eggs. As the season advanced, the number of these eggs in the sea greatly increased, and by March they were more abundant than any other form of marine life found near the surface of the water. So abundant did these eggs become, that on a calm day they could be seen from a boat floating as a thick layer.

By the end of May, the sea swarmed with millions of transparent little cod, about a third of an inch in length. These fish could be seen feeding on the minute crustaceans near the surface. By the end of June the little cod were about an inch in length, and soon after this the majority of them disappeared. Sars again found them early in July, sheltering under large jelly fish. The young cod, which were now about an inch and a half in length, were found to be full of crustacean parasites, known as medusa-fleas, similar to those on their floating shelters. No doubt young cod gather together under the jelly fish in this manner in order to obtain this parasitic food, but incidentally this method of feeding helps to conceal the young fish from attack.

Towards the end of July young cod leave the shelter of the jelly fish and take up their abode in the seaweed amongst the rocks. In a year's time these fish have grown to six or seven inches in length. During their second summer the young cod still keep amongst the seaweed, but towards autumn go out into deeper water.

The cod is a predaceous fish, feeding on whiting, herrings, sprats, small cod and various crustaceans and molluscs, and as nothing appears to come amiss to him the cod rapidly increases in weight. The best-known members of the cod family are the cod itself, the haddock, the whiting, the pollock, the ling, and the hake. From the angler's point of view the pollock is probably the most important. This fish is usually found on a rocky coast, and trawling for him with a short rod and a red rubber sand eel as a bait, often affords excellent sport.

Since Sars first described the egg of the cod, it has been found that with the exception of the herring, all our important food fishes hatch from floating eggs. Apart from their variation in size, floating eggs are not all alike in appearance, and many of them can be recognised under the microscope. For example, the egg of the cod and the plaice consist of a perfectly simple yolk enclosed in an egg membrane. In the turbot, an oil globule is present in the yolk, and further, the yolk may be partially or entirely divided up as, for example, in the egg of the sole and the anchovy.

Floating eggs are present in the sea all the year round, but they are most abundant in the spring.

The time that marine eggs take to hatch varies, as in the case of the eggs of freshwater fish, with the temperature of the water, and with individual fishes.

The eggs of the anchovy usually hatch in two to three days, those of the sprat in three to four days; and it is exceptional for any of the eggs of our food fishes to take more than a fortnight.

The life of the young fish commences as soon as fertilisation of the egg has occurred. After hatching, this life is divided into four stages: larval, post-larval, adolescence and maturity.

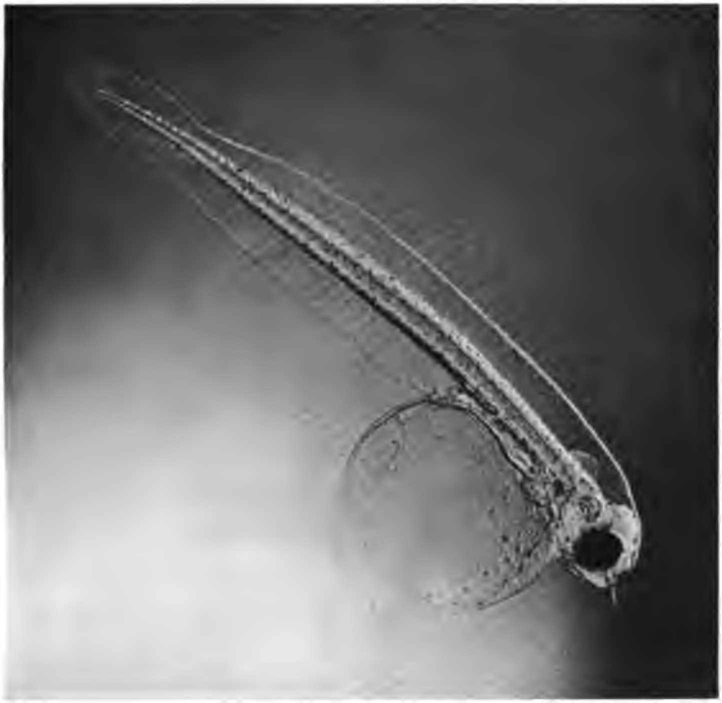
The larval stage extends from the hatching of the fish to the time when the yolk sac is absorbed. When the yolk sac has disappeared the young fish is totally unlike the adult in appearance, and until such time as the appearance of the adult has been acquired the young fish is described as being in the post-larval stage.

Adolescence covers the period from the post-larval stage to the time when the fish develops spawn, after which it becomes a mature fish.

Bearing in mind the size of the eggs of the fish under consideration, it follows that the larval forms of our food fishes when first hatched are exceedingly small; the largest of them, indeed, is only about one-fifth of an inch in length.

As a typical illustration of a fish just hatched from a marine egg, I show a photograph of the larval plaice. The points of interest in its structure are: the simple median fin running from the head right round the tail to the yolk sac beneath, and the pectoral fin seen as a delicate circular flap.

In the head we notice the shape of the brain, the



NEWLY-HATCHED PLAICE.

This may be taken as a typical example of the larvæ of our food fishes.

big eye, the organ of hearing just above it, and the absence of the mouth, which has not as yet developed. Attached to the body of the fish is the large spherical yolk sac, and between the yolk sac and body is seen the intestine as a straight, simple tube. On the body and primitive median fin are shown numerous black and canary-yellow star-shaped colour cells.

Larvæ at this stage are quite transparent, and if seen in a tumbler of sea-water, their eyes only can be detected. The photograph shown was taken by a combined reflected and transmitted light, and thus the edges of the delicate structures are lighted up, while the transparent appearance of the fish is still maintained.

The larva when first hatched floats upside down.

Larvæ of marine fishes, like the trout alevins and the roach larvæ, already described, live for a time upon the yolk contained in the sac. At the end of a week or more according to the particular fish under consideration, the yolk is all absorbed. The mouth has by this time become open, and the fish commences to feed on diatoms and the microscopic larvæ of minute creatures which swarm in the sea. Diatoms are a low form of plant life, consisting of but a single cell, to which further reference will be made in a subsequent chapter.

The fish is now in the post-larval stage and is still transparent. Next, the bony skeleton gradually forms; bony fin rays appear in the continuous median fin, and separate fins are formed; colour cells and light-reflect ing spicules are developed in the skin, and the fish, acquiring the appearance of the adult, now enters upon the stage of adolescence.

This change from the transparent post-larval stage to that in which the fish assumes the shape and silvery appearance of the adult, does not call for our special attention among round fishes, such as the cod, the haddock, and the mackerel. Among flat fish, however, such as the plaice, the sole and the turbot, a remarkable transformation occurs during the post-larval stage.

Flat-fish larvæ begin by swimming near the surface in an upright position like the larvæ of other fishes. Next, they flatten from side to side, and gradually approach the bottom, to end up by lying on their right or left sides, as the case may be.

If no alteration occurred in the position of the eyes when the young fish had settled on the bottom, one eye would be buried in the sand. To prevent this during the transformation of the larval flat fish, the cranium in the region of the orbit rotates on its longitudinal axis until the two eyes lie in a vertical plane, the eye from the underside being above the other. Not infrequently it is stated that the eye from the underside travels round the head, but this is incorrect for, as explained, it is the cranium that rotates, and the relative position of the eyes does not alter.

Plaice, soles, flounders, dabs, lemon soles and halibut, after they have flattened, all lie on their left side, while turbot and brill lie on their right side.

In certain tropical flat fishes the eye appears to travel right through the head to the upper surface. This is due to the fact that in these fish the fin is prolonged on to the head. At first one eye is on either side, but when the cranium rotates the eye from underneath is carried through the fleshy part of the fin.

Attached to the biological station at Port Erin in the Isle of Man, is a fish hatchery. Here, in two large ponds some four hundred plaice spawn every year. The spawning extends over a period of about six weeks, and during this time the floating eggs are periodically collected by means of a large surface net. The eggs are then transferred to the hatchery and in due course the larval fish that hatch are turned into the sea. In 1910, over eight million larvæ were thus hatched and released during the season. As might be expected, several eggs escape collection. These hatch, and grow to small plaice in the ponds. In April and May, 1909, through the kindness of Professor Herdman and the assistance of Mr. Chadwick, I was able to collect several of these plaice larvæ and obtain photographs of them in all stages of their transformation.

Until my arrival at Port Erin, I had no idea that I should have such a grand opportunity for photographing these larvæ, and, in consequence, was unprovided with a suitable apparatus for the work. With the assistance of the local carpenter, however, I constructed a wood, wire and brown-paper extension to my reflex camera, and using an acetylene bicycle lamp as an illumination, obtained the photographs shown on the plates facing this and p. 116.

The three illustrations of the plaice hatching were obtained between 10 p.m. and 5 a.m. after three days' unsuccessful work; but I was well rewarded in the end, for the movements of the young fish emerging from the egg membrane were exceedingly interesting to watch as seen on the ground glass of the camera.

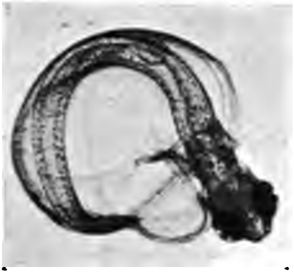
The plaice egg, if rolled between the finger and thumb feels quite hard and shot-like, but in due course the growth of the delicate larva bursts the egg membrane, and some part of the little fish protrudes.

In the hatching illustrations, the first photograph shows the head and part of the yolk sac protruding. In this particular case, the young plaice appeared to take a fixed point with its tail, then alternately straightening and relaxing its back in quick succession, it hammered with its head and shoulders against one side of the rent. In this manner, the egg membrane was sufficiently torn open to allow of the escape of the hatching plaice.

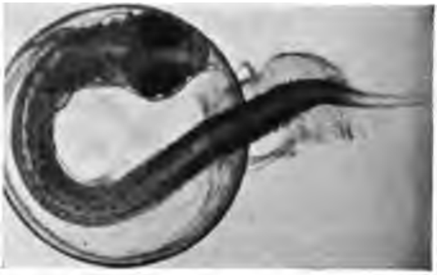
As opposed to this method of hatching, members of the salmon family force themselves out of the egg membrane with a wriggling movement.

The second photograph of the plaice hatching head first, well illustrates the hammering movement described.

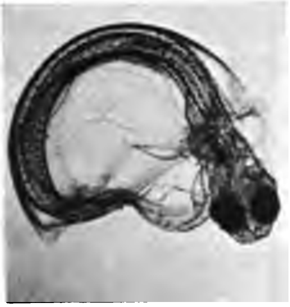
In the illustration of the plaice hatching tail first, it will be seen that the median fin which encircles the



PLAICE HATCHING HEAD FIRST.

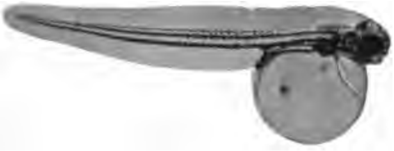


PLAICE HATCHING TAIL FIRST.



PLAICE ENLARGING RENT IN THE EGG MEMBRANE.

1



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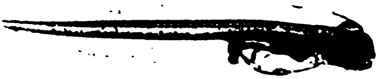

1. PLAICE, NEWLY HATCHED.
2. PLAICE, EIGHT DAYS OLD.

(*See next plate.*)

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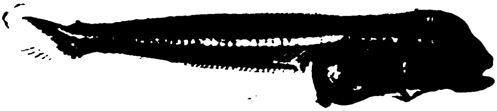
3



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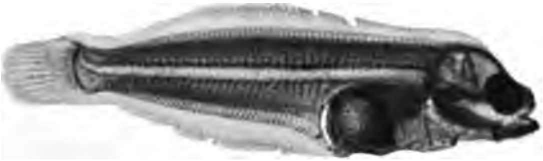

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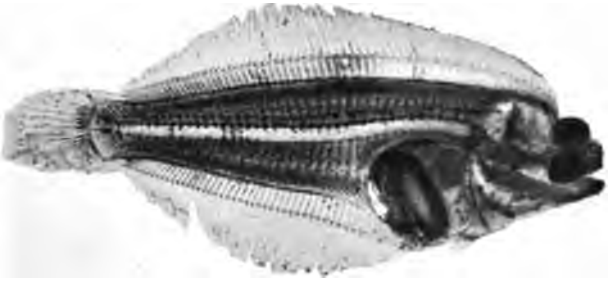

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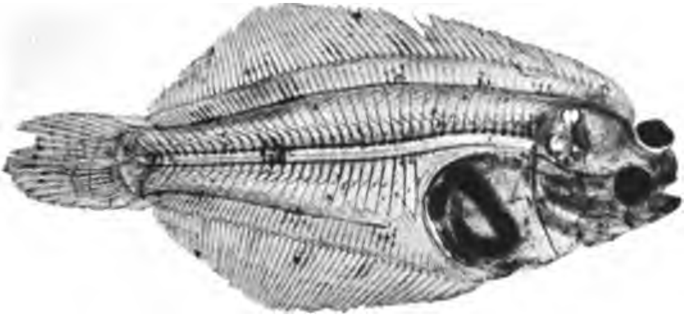

STAGES IN THE TRANSFORMATION OF THE PLAICE, SHOWING HOW THE FISH BECOMES FLAT AND THE LEFT EYE IS CARRIED OVER.

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end of the tail is crinkled in consequence of being pushed through a very small rent in the egg membrane.

The life history of the plaice has been very thoroughly investigated. In the early spring numbers of male and female plaice crowd together on the spawning ground. Millions of eggs are shed, fertilised, and then rise to float during their incubation. Hatching occurs on the average about the seventeenth day. When first hatched, the little plaice is about one-fifth of an inch in length and floats with its yolk sac uppermost. At the end of eight days the yolk sac has practically disappeared, and the little fish now commences to feed on diatoms.

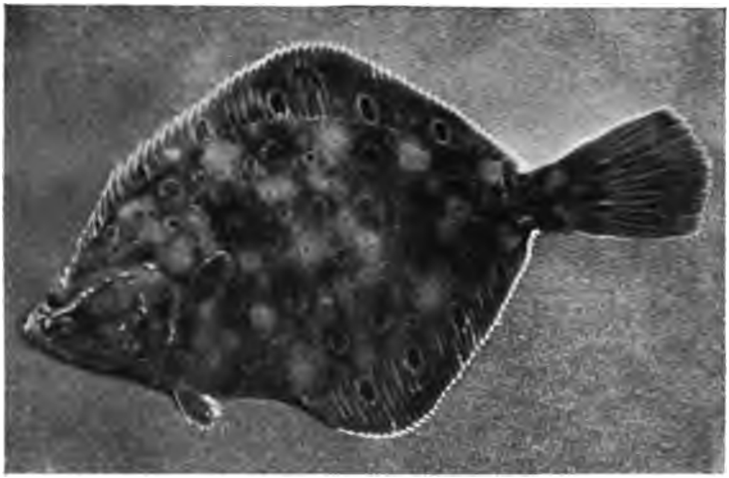
At first the growth is very slow, and at the end of a month the larval plaice is considerably less than half an inch in length, and the eyes are still opposite each other. The fish now increases more in depth than in length, and this is the first indication that the transformation of the symmetrical fish is about to commence.

The head now gradually rotates and the left eye is carried up into a position above the right eye. About the fortieth day after hatching the left eye appears on the brim of the head, and in another five or six days both eyes are in the position which they occupy in the adult. The whole transformation takes about six weeks, and during this time the plaice has gradually been sinking to the bottom, and for the last few days lies on its left side. The upper surface or right side now shows considerable pigmentation, while the lower surface or left side is colourless.

The young plaice are now nearly an inch in length, and gradually make their way toward the shore. Thousands may be caught in a shrimp net, and they are abundant in the pools left on the sandy shore by the receding tide. The subsequent rate of growth, as in all fish, depends upon the food supply; for example, plaice grow much more rapidly on the Dogger Bank than on plaice grounds near the coast. As a fair average, a plaice is about three inches in length at the end of its first year, and in each successive year adds from two to three inches to its length until it is five years old, after which time the growth is not quite so rapid.

Plaice usually spawn when five or six years old, i.e. when they are from thirteen to fifteen inches in length. To know exactly at what age a fish spawns is of importance, for in the distant future, when sound legislation husbands our sea fisheries, it will be illegal to offer a fish for food supply until it has had opportunity of maintaining the continuance of its race.

We have seen how the exact age of the salmon can be read by the rings of growth on its scales. The age of the plaice and other fish can be told by certain light and dark rings seen upon the ear stones or otoliths in the skull of the fish. Looking at the illustrations of otoliths it will be seen that there is a central white portion which indicates the growth of the otolith during the first spring and summer in the life of the fish. The autumn and winter growth is then indicated by a dark



ADULT PLAICE.

POOLS THAT HOLD YOUNG FLAT FISH.

NTOU

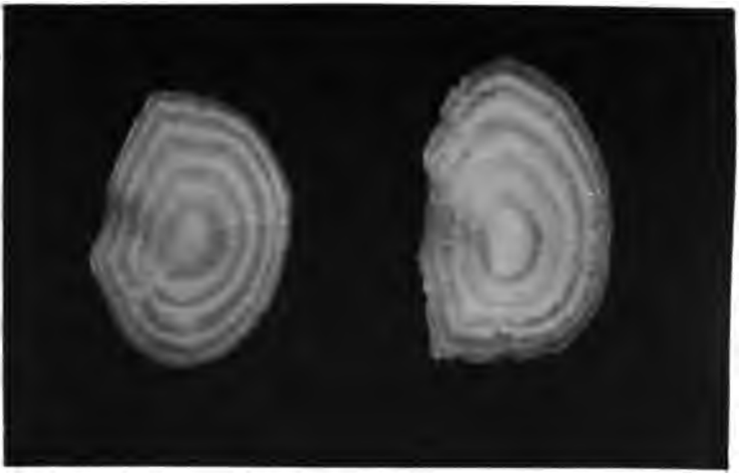
ring and subsequent light and dark rings indicate a year's growth. The rings, as a rule, are quite easy to distinguish and their number bear a regular relationship to the length of the plaice. Thus, in any particular area the length of the plaice is an indication of its age which can always be confirmed by an examination of the otoliths.

Considerable attention has been paid to the examination of otoliths on the Continent and in this country, and naturalists are satisfied that otolith examination is a reliable source of information. But I will describe how every reader of this book can examine plaice for himself, and confirm the relationship of the length and the age of the fish as indicated by the white rings on the otoliths.

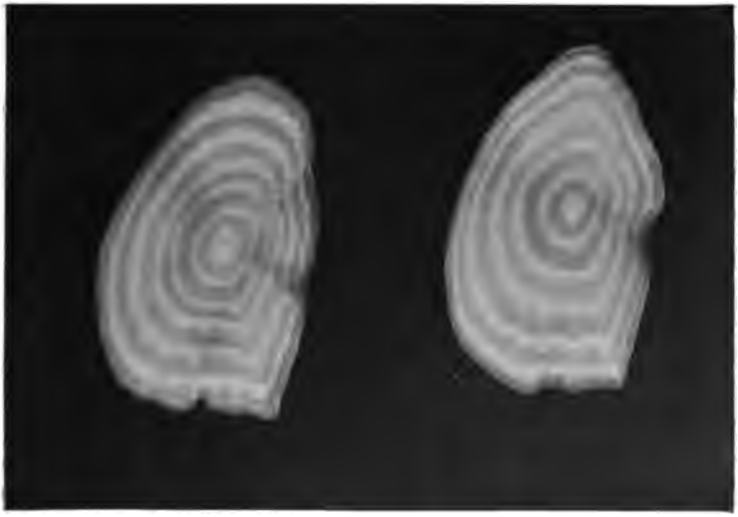
Every morning your fishmonger receives with his consignment of fish a number of plaice. These are neatly laid out on the marble slab, and the housewife comes and selects the particular fish she desires, and then orders it to be sent home filleted. The fishmonger lays the plaice on a board, runs the point of a sharp knife down the whole length of the fish on one side of the backbone. He then makes a cut through the flesh just behind the gill-cover, and with a dexterous sweep of the knife the first fillet is cut clean off the bones. In a similar manner, a second fillet is taken off the other side of the backbone. The plaice is now turned over and two more fillets similarly removed. After a plaice has been filleted, the bony skeleton is as perfect as before the fillets were removed, and the relative position of the bones of the body, the head and fins remains the same. If all the skeletons which have been thrown aside are gathered at the end of the day, it will be found that they can be divided into groups of certain sizes. In the month of May, I found that the plaice in my fishmonger's shop, with very few exceptions, could be divided into three groups, namely, a group of fish from fourteen to fifteen inches in length, another of about eighteen inches, and lastly, of fish from twenty to twenty-one inches. I took twelve fish from each of these groups and by examining the otoliths could read quite clearly that these plaice were respectively five, six and seven years old. I have never seen otoliths scientifically removed, but it is a very easy matter to get out the right and left otoliths in a few minutes from a number of plaice.

Put the plaice on a board on its left or colourless side. Take the fishmonger's largest knife and lay the edge of it along a line from the upper margin of the pectoral fin to a point an eye's breadth above the upper eye; then strike the back of the knife a sharp blow with a mallet and cut right through the head.

You will find that you have opened up a hollow space in the skull which is the front part of the cranial cavity. The back part of this cavity still has a dome-shaped covering of soft bone over it. Slip the point of a smaller knife under this dome-shape covering and cut directly upwards. Then pull open this back part of



Otoliths from group of Plaice 14½ in. in length and five years old, showing white centre, and four white rings.



Otoliths from group of Plaice 18 in. in length and six years old, showing white centre and five white rings.

HOW TO READ THE AGE OF A PLAICE BY THE RINGS ON THE OTOLITHS OR EAR-STONES.

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the cranial cavity and an otolith will be found on the right and left side.

In the illustrations of four otoliths facing p. 118 the two top photographs are of otoliths removed from a group of plaice fourteen and a half inches in length, and show a central white portion which indicates the first year's spring-summer growth of the fish. Then follow four white rings indicating that the fish in this group were five years old. The two lower otoliths were fish from the second group, measuring about eighteen inches in length. These fish were the next in size and a year older, and the otoliths show an additional white ring.

The method of colour protection in flat fishes has already been briefly referred to. Reflection plays very little part in the concealment of flat fishes, for they depend on becoming light or dark to suit the general tone of their surroundings by the contraction or relaxation of existing colour cells. The variation in the markings and colour of young flat fishes is very great.

The expert can recognise the tiny plaice, sole, lemon-sole or flounder by their shape, but it may be useful to the uninitiated to remember that if a finger is run along the upper surface of the fish from the tail to the head, the plaice feels quite smooth, the sole rough, and the flounder rough only along the centre line.

Of round food fishes we have already referred to the cod family, another important group is to be found in the herrings, which include the herring, the sprat, the pilchard, the shad and the anchovy. These fish swim in shoals, and are usually to be found in mid-water or near the surface at no great distance from our coast. Herrings feed entirely upon crustaceans, which swarm in the sea, and they strain this food from the water by means of a sieve-like arrangement in the throat. When considering the throat teeth of the carp, I referred to the bony bars on each side to which are attached the gill filaments. In the herring, on the first pair of bars are rows of stiff pointed projections like the teeth of a comb. These projections are known as gill-rakers. It is by means of these gill-rakers that the food of the herring family is strained from the sea.

The herring and the sprat often frequent brackish water, and as already stated, herring frequently spawn in water sufficiently fresh to permit of their eggs being attached to the leaves of fresh-water plants. The shad ascends into fresh water to spawn, but the pilchard and anchovy keep entirely to the sea.

In the herring family we have examples of the three types of eggs found among bony fishes. The eggs of the shad are heavy, but free from each other, and lie on the bottom like the eggs of the salmon. Herring eggs are heavy and adhesive and are attached to stones and gravel, while those of the sprat, pilchard and anchovy float like those of the plaice and cod.

Herring spawn is deposited during the summer and again in the winter, but the same fish does not spawn twice in one year, for it is now known that summer-spawning and winter-spawning herring are fish of a different race. The latter deposit their eggs in brackish water, whereas the former spawn at a considerable distance from the coast.

The herring egg hatches in about a fortnight and the larval fish that appears differs from the plaice larva, previously described, in that it is already advanced further in development and the mouth is opened.

At first the young herring grows mainly in length, and when about an inch and a half long is an attenuated little fish, perfectly transparent, and devoid of scales. The transformation of the larval herring occurs two to three months after hatching, when the fish is one and a half to two inches in length. This change consists in the appearance of scales, while at the same time the fish becomes silvery and the body increases in depth.

The larval sprat goes through a similar transformation, and both these fish are met with as whitebait when from one to three inches long.

In February, March and April, 90 per cent. of whitebait consists of sprats, but in July, August and September the number of small herrings greatly predominate.

The pilchard is to be found inhabiting the sea from the southern shores of our country right into the Mediterranean. Caught off the Cornish coast, the fish is known as a pilchard, but when taken in French waters it is called a sardine. Many people think that when they purchase a tin of small-sized sardines, that they are procuring the genuine article, and that the tins of larger fish are not sardines at all. But the small-sized sardine is a one-year-old pilchard, whereas the larger size is merely an older pilchard.

Of all our food fishes probably the mackerel is the most beautiful, with its alternating zig-zag bands of black and green, its metallic iridescence, ranging from a silvery hue to a coppery gold, and its changing colours from a yellow to a beautiful pink.

In the spring and early summer mackerel feed on minute free-swimming crustaceans, such as copepods, and mysis (a mysis is illustrated on the plate facing p. 152), and on the medusa-fleas which frequent jelly fish. This food is strained from the water by the gill-rakers of the fish which are as well developed in the mackerel as in the herring. In the late summer and autumn mackerel feed on small pilchards, sprats, rocklings and sand eels.

The mackerel is a summer spawner, and the floating eggs are found round our shores in May and June.

The seasonal migrations of this fish have always attracted great interest. Broadly speaking, the mackerel is practically absent from the Cornish coast from November to January. With approaching spring it is caught in the Atlantic at first some distance out, but by May huge shoals have come right in shore. These fish are abundant during June and July, but become scarce in August and then disappear. They turn up again for a month late in September, and then again disappear until the following May.

Off the Norfolk and Suffolk coasts mackerel are caught in May and June, and again for about six weeks during September and the beginning of October.

The probable explanation of these migrations of the mackerel is as follows:

In the spring, the fish come in shore to spawn, and then move back into deeper waters off the coast. Their reappearance during late summer and early autumn is due to their following up the inshore migration of larval fishes, for it has been abundantly proved that though mackerel usually feed on copepods and other free-swimming crustaceans, in late summer and autumn, their food mainly consists of young fish.

With the approach of winter the sea round our shores cools down, and as a temperature of less than 45° F. is uncongenial to the mackerel, they disappear to the warmer waters of the Atlantic. The gradual return, as stated, during the following spring can be traced by the fish being caught nearer and nearer to our shores as the spawning season approaches.

Thus we see that the spawning instinct, food supply and the temperature of the water all play their part in the migrations of the mackerel.

But for marvels of migration we have to turn to the life history of the common eel. For many years peculiar forms of fish life, known as leptocephali, have been recognised in the sea. These leptocephali possess perfectly transparent ribbon-like bodies of considerable depth, and flattened from side to side. The head, as indicated by the name, is exceptionally small, and they vary in length from three to five inches

For a time leptocephali were thought to be a distinct species, but about twenty years ago, Grassi, the Sicilian naturalist, by examining specimens obtained from the stomach of the sun-fish, discovered that leptocephali were the larval forms of the eel family. It is only within the last year or two, however, that the life history of our common eel has been partially worked out.

Eels are present in almost all the fresh waters of Europe, and on the Atlantic side of North America. Two varieties are frequently described, viz. the broad-nosed and the sharp-nosed eel, but these are really one and the same fish, the former being the male and the latter the female.

[illegible]

Male eels are usually found near the sea in brackish water, and in the mouths of rivers, whereas the females occur in every pond and stream. In October and November immense quantities of eels make their way down the river and descend into salt water. When confined in ponds without an outlet, eels frequently travel overland in order to reach water that communicates with the sea.

Now comes a break in our knowledge of the exact journeyings of the eel, although there is sufficient evidence to make it highly probable that these fish shed floating eggs many hundreds of miles out in the Atlantic.

The transformation from the leptocephalus to the eel, however, has recently been thoroughly investigated on the cruises of the Danish research boat *Thor*, and is beautifully illustrated in the Science Museum at South Kensington.

The leptocephalus does not feed in the sea, and consequently a reduction occurs in the length, depth and weight of the fish. In this manner the flattened leptocephalus is gradually transformed into the rounded glass eel. The glass eel is shaped very much like the elver, or young eel, but is still quite transparent. Later, glass eels become pigmented, and, as elvers, during the summer ascend our rivers in countless millions.

During the voyages of the *Thor*, the greatest number of leptocephali were found in the comparatively shallow waters of the Continental shelf, off the south-west coast of Ireland—consequently, this part of the Atlantic was thought to be the spawning ground of the common eel. But new light has recently been thrown on the wonders of eel migration during the North Atlantic Expedition, under Sir John Murray and Dr. Hjost, in 1910. Leptocephali of the common eel, measuring about three inches in length, were found north of the Azores undergoing transformation. Others were taken south of the Azores over a thousand miles from the mainland. These were considerably smaller in size, and were not yet full grown, and moreover were captured near the surface. It is reasonable to assume, that the smaller specimens were nearer the spawning grounds, and that these spawning grounds were not off the Irish coast, but probably in the centre of the Atlantic.

The young leptocephali are probably carried by the Atlantic drift towards the northern shores of Europe, and when they arrive on the Continental shelf, they complete their transformation and ascend fresh water as elvers.

Sir Herbert Maxwell in his book on "British Freshwater Fishes" explains how an eel is able to travel for long distances across land. This is due to the fact that the eel does not have one gill cover and one gill opening, but several gill slits behind the pectoral fin. Within each gill slit is a gill cavity, and further, each gill slit can be closed by a membrane stretched on delicate bones. In consequence of this arrangement the eel can retain a considerable amount of moisture in the gill cavities, which keeps the gill filaments afloat. This accounts for its power of living out of water when travelling over land.

In summing up the migrations of the eel, we see that the fish may travel overland from an inland pond to the nearest water that communicates with the sea—then descending the river the eel may journey hundreds or even thousands of miles out into the centre of the Atlantic. Here she spawns, and the leptocephali hatched from the eggs are carried by the Atlantic drift towards the shores of Northern Europe. The transformation occurs during the latter part of this journey, and is completed in the shallower waters of the Continental shelf, where the leptocephalus becomes a glass eel. The glass eel in turn becomes pigmented, and as an elver, or young eel, ascends into fresh water. In due course small eels make their way during floods and rains to the inland ponds.

Eels may live in ponds for many years, and grow to several pounds in weight before they descend to the sea to spawn. But after spawning they probably die, for adult eels have never been known to return from the sea to fresh water.

From the brief description given, it will be seen how very different are the life histories and habits of our food fishes. Many of the methods employed by fishermen in capturing fish from the sea, are based upon a knowledge of these habits. For example, at sundown herring and sprats turn their heads from the shore, and slowly advance in immense shoals as they strain their food from the water. For the capture of these fish, therefore, a wall of netting known as a drift-net, is floated in the sea, parallel with the shore. The fish as they advance push their heads through the meshes of this net, and are held captive by the strands slipping behind the gill covers. In autumn eel-baskets are placed across the river to intercept the passage of these fish on their migration to the sea. The trawl on the other hand, sweeps up everything from the bottom, mature and immature, useful and useless fish alike. Though the trawl is the most ready method of procuring fish, it is at the same time the most harmful to our sea fishes.

A brief description of the various methods of fishing in the sea may be of interest to the reader.

All round our shores a considerable amount of fishing is done with hand lines carrying two or three hooks; or with comparatively long lines which lie on the bottom and carry some hundreds of hooks. Few, however, realise on how large a scale line fishing is conducted in the open seas.

Long-line steamers, fitted with every modern convenience, fish in seas beyond the North of Scotland, where halibut, cod and hake abound. The fishing equipment of a "long liner" consists of several lengths of lines. To these long lines, at intervals of six feet apart, are attached short lengths of lines known as "snoods." Each snood carries a hook. The hooks are baited on shore with herrings, sprats, pilchards, mussels, whelks, squids or lug-worms. Each length as it is baited is coiled round and round in a tub; the baited coils are separated from each other usually with a whisk of bent grass.

As soon as the fishing ground is reached one end of the length of line in the first tub is attached to a buoy and then the rest is paid out. To the other end of this line is attached the length of line from the second tub, and so on until in the end three to four miles of continuous line, carrying one to two thousand hooks are laid on the sea bottom. At various points along this line are attached lead weights and buoys.

The fisherman does not shoot his gear haphazard. Grounds likely to be productive of good fishing are known to him, and, further, during the herring spawning season it is not unusual to search for the eggs of these fish with a well-greased sound, for where the herring spawn is, there the haddock are gathered together.

It is worthy of note that when an exceptional catch of haddock is made, if the stomachs of these fish are examined they will frequently be found to be full of herring spawn.

The long line is usually left down during the night, and weather permitting is fished the following day. In rough weather, however, it may be impossible to take it up for several days, and then as already stated, dogfish play havoc with the catch.

Halibut, cod, haddock, skates and rays are the more important of the marketable food fishes taken on the long line.

Of the various nets the trammel, the seine, the drift-net, and the trawl are the only ones that call for our attention. The trammel is not a single net, but consists of three perpendicular walls of netting set in the sea alongside each other, and at right angles to the shore. Each wall of netting is corked above and weighted below. The two outer walls of netting have a large mesh, whereas the mesh of the centre net is quite small. Further, the central net is twice the length of the two outer nets, but is gathered together and set slack so as to hang between them. The trammel catches fish as they swim along the shore and is mainly used to procure such fish as mullet and bass. A mullet coming, say, from the right, swims through the broad meshes of the outer wall on the right, comes in contact with the central net, and then swimming on carries a portion of this slack net through the broad meshes of the net on the left. He is then checked and held in a pocket of small mesh netting from which escape is impossible. Fish coming from the left are caught in a similar manner by carrying the central net through the broad-meshed net on the right.

The seine in its simplest form consists of a single net some three hundred feet long and twelve feet in depth. When used in shallow water, one end is made fast to the shore. The net is then dropped in a semicircle from the stern of a boat, the free end being brought back to the shore. Both ends of the net are now seized and hauled in, and the fish are gradually drawn into the central portion of the net and hauled ashore.

Seining for pilchards on the Cornish coast is a more elaborate procedure. First, the shoals of fish are located by a man who watches for them from the cliffs, not infrequently from a tower built for the purpose. This man is known as a "huer." As soon as the huer detects patches of a reddish appearance in the sea, he knows that the pilchards have arrived. Then by weird sounds and signs, he communicates the information to the fishermen in the sleepy village below. All is at once bustle, and the long tarred seine boats, which are ready on the shore, immediately put out to sea, and the annual pilchard fishing commences.

The huer, by signs continues to direct the boats to the teeming fish. Four boats accompany each net; the large seine boat (over thirty feet in length) is rowed by six men, while two others work the net. From two smaller boats is worked a stop-net, and in the fourth boat is the man who directs the proceedings.

The drift net consists of several nets connected together in one long line, each boat having a fleet of sixteen nets. These nets, corked above and leaded below, are set parallel to the shore. When in position the drift net presents to the advancing shoal of fish, a perpendicular wall, twenty-four feet in depth and often two miles long. The nets, when connected together, are spoken of as " trains " or " fleets."

The drift net is not fixed, but floats with the tide, and can be used in any depth of water for the capture of surface-swimming fishes, such as the herring, the pilchard and the mackerel. The method by which fish are caught in this net has already been described, and every visitor to a fishing port has seen the fishermen sitting on up-turned buckets and empty boxes, passing the net along from a heap in front of them to a heap behind them, and dexterously extricating the herrings that have been caught by the gills.

Lastly, we have the most important method of all: the trawl. Small trawls are worked round our shores for plaice, whiting, lemon-soles, dabs, skates and rays. But the deep-sea trawler captures in addition, turbot, cod, halibut and hake.

Until quite recently the largest trawler was a sailing vessel manned by four to five hands; this boat carried a beam trawl, which had a spread of some fifty feet on the sea bottom, and fifty fathoms of water was the limit in which this net could be worked. Now the modern trawler is a much larger boat, and carries two "otter" trawls, each with a spread of one hundred feet, and while one trawl is gathering up everything from the bottom at a depth of a hundred fathoms or more, the fish from the other trawl are being sorted and gutted.

As an illustration of the catches these boats sometime make, I quote from the *Fish Traders' Gazette*, of June 3rd, 1911.

"The largest halibut on record arrived at Billingsgate market last week. It weighed some seven hundred pounds, or nearly one-third of a ton, and was part of a catch of one hundred tons of fish from the White Sea, landed by the trawler *Macfarlane*, of Hull."

This leviathian took six porters to carry it.

To those interested in our food from the sea, a morning at Billingsgate well repays the trouble of an early rise. The incessant string of porters in their white overalls and quaint shaped hats, the loud tones of the auctioneers, and the clatter of boxes, as tons of fish are deposited on the floor, makes a scene of animation seldom met with. Do not go, however, in your patent leather shoes, as I did on the occasion of my first visit, for I had crept out of the house where I was staying at 4 a.m., and at that time in the morning hesitated to ring for my boots.

At Billingsgate, seven hundred tons of fish are sometimes delivered in a day, but Billingsgate is a small market compared with Grimsby and others.

The smallest trawl used round our coast is the shrimp trawl, with a spread of about twenty feet. If the reader has never seen a shrimp trawl hauled, he should take the first opportunity of doing so. Shrimps may or may not be present in large numbers, but thousands of other forms of marine life are sure to be caught, including tiny soles, plaice, dabs, codling, whiting, sand-eels, pipe fish, gobies, silvery sticklebacks, crabs, star-fish, sea-urchins, and hosts of other interesting objects representing both the animal and vegetable kingdom.

Before leaving the subject of nets, I should like to refer to the difference between the beam and the otter trawl. In the former the mouth of the net is kept open by means of a beam, which may be as much as fifty feet in length. This beam is raised two or three feet from the bottom by means of stirrup-shaped iron contrivances at each end, the beam being attached to the top of the stirrup, while the flat part or shoe of the stirrup glides along the ground. Fastened to the bottom of the stirrup is a length of stout rope half as long again as the length of the beam. As the trawl is dragged along, this rope, known as the "ground line," naturally forms a semicircle. Along the beam is another rope, the "head line," which is the same length as the beam. To these two ropes is attached the netting of the trawl. The net itself is cone-shaped, and the end of the cone, known as the "cod end" is open, in order to let the fish out. When being fished the cod end of the trawl is tied up with rope.

In the otter trawl, the beam is dispensed with, and the mouth of the net is kept open by means of two "otter boards." These boards may be six to seven feet high and three feet wide. To the top of each board is attached the head line, and to the bottom the ground line. In large trawls the head line may be one hundred feet in length, while the ground line is half as long again. The trawl is hauled by two steel wire ropes, often a mile in length. Each rope is attached to an otter board in such a manner that as the vessel advances, the boards incline outwards from the mouth of the trawl. Thus the rush of water forces these two boards apart, and the mouth of the net is kept open.

The "harvest of the sea" is a term with which most of us are familiar. But the term is a misnomer. Harvest implies that man sows and reaps the result of his labours. In the sea Nature sows, and man in gathering the crop does immense harm to the supply in the future by the destruction of immature fish.

Round fishes, in consequence of their habits, have not suffered to the same extent as the fishes that live on the bottom, nevertheless, the North Sea is gradually being emptied of its fish life, and in consequence the fisherman has to go farther afield. It is small matter for wonder that the sole is scarce and that plaice are rapidly diminishing in numbers when one thinks of how the fishing grounds are being constantly scraped by the nets of English, Dutch, French, German, Swedish and Norwegian trawlers.

As an illustration of the intensity of fishing in the North Sea, I quote from the experiments of the Marine Biological Association, conducted by Professor Garstang. In one year alone fifteen hundred plaice were marked with metal tabs, and released outside the three-mile limit. Within twelve months twenty-one per cent. of these fish were recaptured, and returned to the Lowestoft station of the Association. On the Dogger Bank no less than forty per cent. of marked plaice were recaptured. As these marking experiments were done with the object of tracing the growth and migrations of the plaice, it necessitated the return of the fish itself to the station. We may, therefore, reasonably presume that twenty-one and forty per cent. does not represent the total capture of marked fish, for in some instances the tabs would escape the notice of the fishermen, and in a few cases the fish would not be forwarded.

In consequence of this intensity of fishing, the Dogger Bank now holds no indigenous plaice, but depends for its supply upon the annual migration of fish from the coastal grounds.

Not only are the larger plaice and other flat fish decimated in this manner, but countless millions of small soles, plaice, dabs, whiting and cod are destroyed round our shores in the shrimp trawls. Cunningham gives the result of one and a half hour's haul with a twenty-one foot beam trawl outside the mouth of the Mersey, and during the capture of thirty-two quarts of shrimps, no fewer than 10,407 plaice, 875 dabs, 169 whiting, 69 codling, and 12 soles were also taken. All these fish were small in size, and 7,000 of the plaice were so small as to pass through the meshes of a shrimp riddle.

The injury to immature fish occurs when the cod-end of the trawl is hoisted out of the water; for then the fish are packed together in a solid mass, and those at the bottom are crushed beyond recovery by the enormous weight of fish above them.

The remedy for this depletion of fish around our shores lies in sound international legislation, which will protect immature fish, and at certain seasons their spawning grounds.

The "man in the street" seldom gives a thought to the marine biologist, or if he does, in many instances, he merely thinks of him as a scientist who catches and examines queer creatures in the sea for a purpose which he cannot understand. But the whole question of harvesting our food supply from the sea depends upon the knowledge gained by the marine biologist concerning the life histories, migrations, food, rate of growth and spawning grounds of our food fishes.

Without this knowledge no sound legislation could be passed.

There is, however, a ray of hope for the future, for now nine nations have combined to explore thoroughly the conditions of life in the North Sea. It is possible this may lead to useful results.

Some may say: "Why this fuss about the North Sea? There are plenty of fish in other parts of the ocean."

Certainly! But year by year the trawler has to go farther afield, boats have to be longer away, wages have to be paid, and this all adds to the cost of fishing, and if this depletion of the North Sea continues, the catch phrase which has in recent years been heard in more than one election, may come true: "Your food will cost your more."

As to the possibilities of harvesting our food fishes, we have a good illustration in the recent experiments of the Marine Biological Association. Large numbers of small plaice were captured on the coastal grounds. These fish were marked, and certain of them were then released on the same grounds, while others of them were transplanted on to the Dogger Bank. Within seven months the plaice on the Dogger Bank were six times the weight of the fish on the coastal ground. It has been calculated that as a commercial enterprise alone, transplanting plaice to the Dogger Bank would be a success, and incidentally it would materially assist to increase the number of large plaice in the North Sea.

The above description of food fishes has necessarily been of a sketchy character, but I would refer those interested in our sea fishes to such books as "British Marketable Marine Fish," "British Marine Food Fishes," "British Salt Water Fish," and "Conditions of Life in the Sea," respectively by Cunningham, McIntosh and Masterman, Aflalo, and Johnstone.

CHAPTER VIII

HABITS OF MARINE ANIMALS

My brother has accompanied me on several of my photographic holidays, and had it not been for his assistance many of the illustrations shown would never have been obtained.

Often two or three days, and a considerable part of the night, have had to be spent closely watching a fish in order to photograph a particular attitude, movement, or stage in its life history. After a spell of this sort it comes as a pleasant change to take a day off and either photograph marine animals amongst the rock pools, or attempt to emulate the Keartons by obtaining sun pictures of bird life. For this sort of photography no special apparatus is necessary. I merely take a quarter-plate reflex camera, twelve dark slides, and then scramble amongst the rocks, looking for objects of interest.

It is a wise precaution to have everything strapped on, otherwise with your hands hampered you may slip on a weed-covered boulder, and have to look for your camera or plate-box at the bottom of a pool.

There are two ways to work on these excursions. You may either keep on the move, picking up here and there photographs of varying subjects—and it is astonishing how often negatives taken at totally different times and places will piece together to illustrate the life of any particular animal—or you may adopt the more interesting method of devoting your attention to some individual form of life, say, for example, the sea-urchin.

Sea-urchins are to be found everywhere, but I have never seen the common sea-urchin (*Echinus esculentus*) in greater numbers, more beautiful in colour, or larger in size, than on the old breakwater at Port Erin. Here the sea is generally clear, and on a still day these urchins can be watched as easily under ten feet of water, as when they are only a foot or two below the surface.

It may seem strange that the sea-urchin should be classified by zoologists with star-fishes, brittle stars, and sea-cucumbers, but close examination will show that in their structure they are very similar.

The common star-fish (*Asterias rubens*) with which most of us are quite familiar, has five fingers, and in a groove along the under-surface of each finger are numerous semi-transparent structures known as tube-feet, each of which is capable of expansion and contraction and terminates in a sucker. By means of these tube-feet the star-fish attaches itself to rocks, and also moves about. If an attempt is made to pick a star-fish off a rock under the water, considerable force may have to be exerted, and many of the tube-feet will be torn away.

In the sea-urchin nature has bent up these five fingers and made them meet on the top. The flat star-fish thus becomes the rounded urchin, and the under-surface of the five fingers of the former, are now on the outside of the latter, and thus the tube-feet in the urchin are arranged along five radii from the base to the apex of this dome-shaped echinoderm.

With its tube-feet the urchin attaches itself to rocks, stones and weeds, and uses them also as a means of progression. When used for the latter purpose, the tubes are extended and attached to the rocks by means of the suckers, and then by their contraction the urchin pulls himself up to the points of attachment.

These tube-feet are only visible when extended, but the numerous spines on the outer cover of the urchin are apparent at all times, and each has a cup-shaped base which works on a knob on the outer cover, thus giving the spines a considerable range of movement. Though mainly provided for protective purposes, the urchin uses these spines as an adjunct to the tube-feet, in order to steady himself as he climbs or moves about. When in a hurry, however, he is able to scuttle along level ground on his spines alone, without using his tube-feet. The mouth is in the centre of the under-surface, and is furnished with five sharp cutting teeth, which are easily seen. Among the other functions of the tube-feet is that of carrying food to the mouth.

It was low tide as we climbed along the old breakwater, and numerous urchins, the size of large oranges, were high and dry, attached to the concrete blocks. The photograph of one taken in this position shows how the tube-feet were stretched to their utmost whilst supporting his whole weight unassisted by the buoyancy of the sea. Attached to a rock near by, we found a fine specimen only a few inches under the surface; my brother took off his coat and held it as a shield to cut off the light from the sky above, and then hanging over the edges of the rock I waited for the moment when the water was slack, just between two incoming waves, and obtained a photograph as shown.

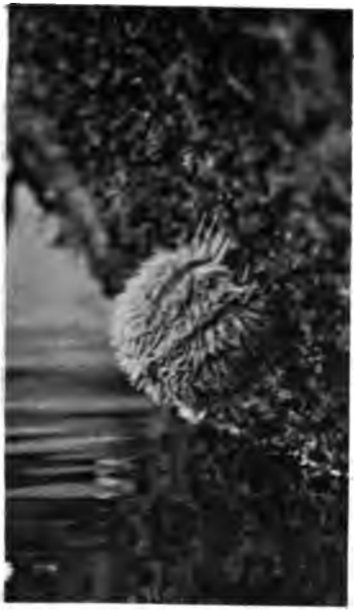
Next we collected a few specimens and carried them to the shore, and placed them in a quiet rock pool. In this position the urchin at once realised that he was exposed to attack, and extending his tube-feet he grasped the seaweed around, and pulling the leaves over him, in ten minutes was out of sight.

We also took back a specimen to photograph in the tank on the following day.

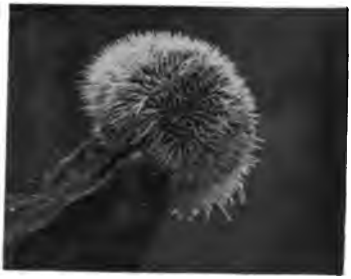
The urchin was placed on a projecting point of rock to which he soon attached himself, but this position was not to his liking, and in the right-hand bottom corner of the dome, several tube-feet are to be seen pawing the water, as the creature endeavoured to get hold of something solid in order to climb down from his uncomfortable perch.

When placed in a tank devoid of seaweed, the concealing instincts of the urchin made him cover himself up with stones and shells in his desire to escape detection.

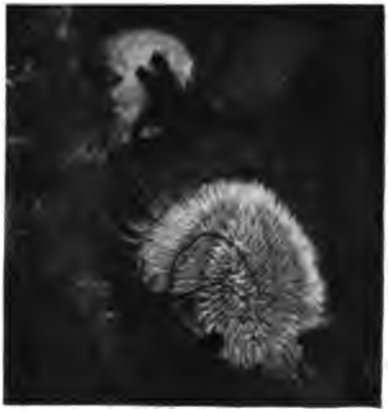
The urchin is edible, and I have heard that he is



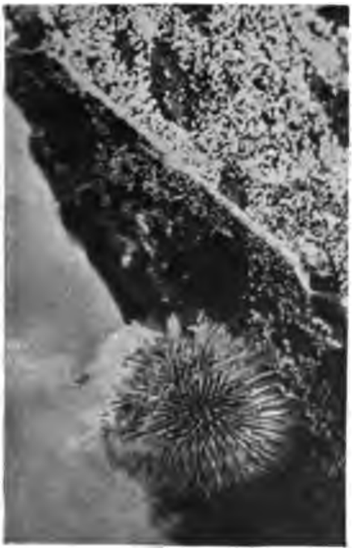
High and Dry.



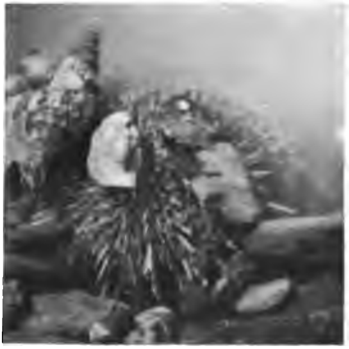
Tube-feet extended.



Covering itself with seaweed.



Under the water.



Covering itself with stones.

THE COMMON SEA URCHIN.

most delicious, though I have never ventured on one myself.

Occasionally I have had the good fortune to join a dredging party, and then specimens can be obtained which are not to be found on the sea-shore. Amongst the bivalves brought up in the dredge, one of the most interesting is the scallop. There are various members of the scallop family (*Pecten maximus*), the largest of them, however, is the one shown in the illustrations.

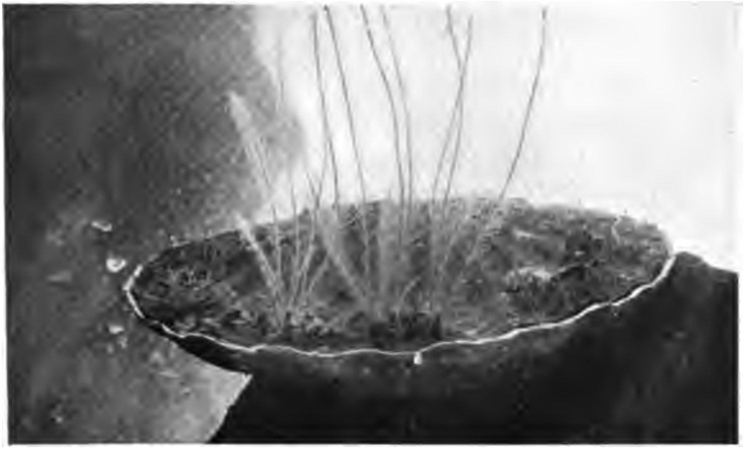
The living scallop can sometimes be obtained from a friendly fisherman, but if you are desirous of examining this, as well as many other interesting specimens, a naturalist's dredge is not an expensive apparatus, and can be worked from a small sailing boat.

When you have got your scallop, place him in a basin of water, keep him in a cool, shady place, and if you frequently change the sea water, he will remain healthy and vigorous for a long time. We are most of us familiar with a scallop shell, the cook has served up many quaint dishes in it, and we have also seen it ornamenting the cottage window sill. Let us now examine the living specimen.

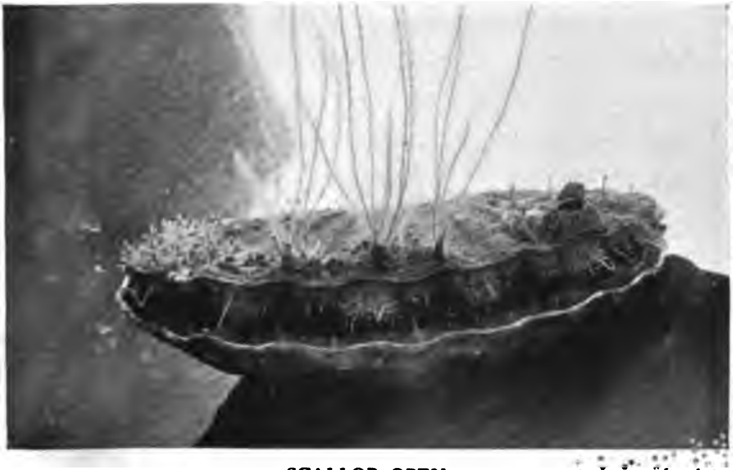
I placed a really fine scallop on a rock in a large glass tank, through which I ran a constant supply of cool sea water from the storage tank used for the spawning ponds at Port Erin. The light was strong, and so for many hours he would not open, which gave me an opportunity for examining the numerous forms of animal life which had fixed themselves upon his flat upper valve. These included several molluscs, and the feathery growths well shown in the photograph, the latter being colonies of hydroids, which, had they been undisturbed, would have given birth to many thousands of jelly fish.

After a time the scallop slowly opened, as shown in the illustration. This is the position in which he lies on the sea bottom, and as the water passes between his valves, he extracts from it the numerous forms of minute life upon which he exists. The fringes all round the top and bottom valves are parts of the mantles; the space between the mantles and the internal organs in bivalves is known as the mantle-cavity, and in this mantle-cavity are the gills. As the scallop lies on the bottom, a hungry crab may attempt to introduce his claws between the valves in order to pull out a dainty meal, or the shadow of a skate may pass over him. In either case the valves would instantly close with a snap. How is it that the scallop is able to detect these enemies, and how does he shut up so rapidly in order to defend himself from attack?

It will be seen that the free edges of the mantles are prolonged into delicate sensory tentacles, and these feel the touch of the crab's claw in the darkest depths. These tentacles also prevent unsuitable matter from passing in between the valves, for should anything come up against them, the valves partially close with a little jerk, and shoot out a stream of water which, causing a current, washes the undesirable matter away.



SCALLOP (*Pecten maximus*) **SHUT.**



SCALLOP OPEN.

The scallop detects the shadow of the passing skate by means of several eyes arranged in a row along the border of each mantle, just under the valves. In *Pecten maximus*, the bivalve under consideration, there are from eighty to one hundred and twenty of these eyes, and nothing is more beautiful in marine life than the two circular rows of eyes, sparkling like precious jewels.

When photographing the scallop shown I had to be very careful not to let my shadow fall on him, or he would instantly have shut up, and I should then have had to wait at least half an hour before he had again fully opened.

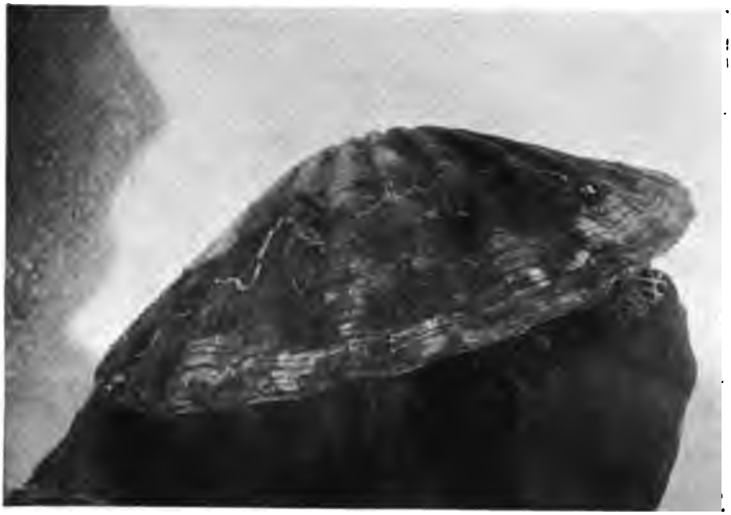
Next, as to how the scallop opens and shuts. The two valves work on a hinge, and when the *pecten* is at rest these valves gape open. They are closed by the contraction of a strong muscle which is attached to each of them on their inner surface.

There are several movements which the *pecten* is able to perform. It may jerk itself back a few inches from some irritating object, it may rise from the bottom and swim in a characteristic manner (as if taking a series of bites out of the water), and if in good health it will always right itself in a few seconds or minutes when turned over on its flat valve.

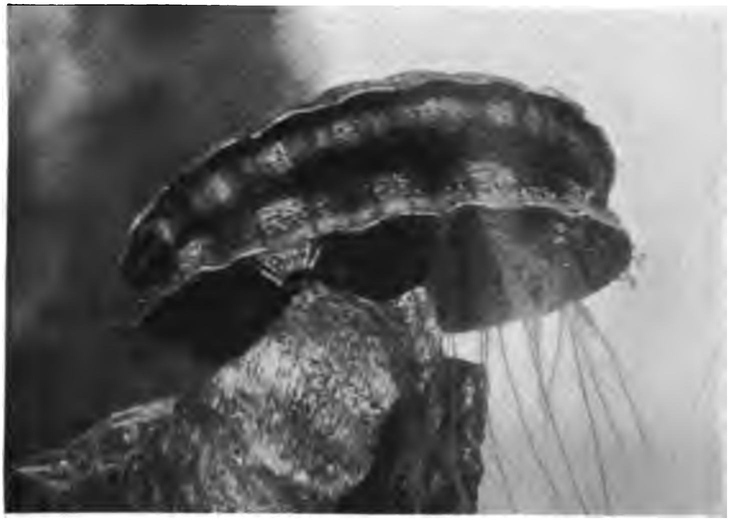
It was my good fortune to meet Dr. Dakin, of Liverpool University, who has made *pecten* a subject of special study, and with his assistance I was able to take a photograph of this act of turning over, and further, Dr. Dakin explained to me how the various movements were performed.

These movements are produced by the combined action of the powerful muscle between the two valves and the mantle edges. By the contraction of the muscle referred to, the shell is closed and the contained water is shot out. The mantle edges determine the position of the exit of the water. If they prevent any water from leaving in front, it is shot out in two streams near the hinge behind, and the animal swims. If the water is allowed to pass out in front the scallop jerks itself back a few inches with the recoil. If a *pecten* is placed on the "wrong" valve (the side marked by the growth of zoophytes, sponges, and barnacles) it soon opens, much wider than is usually the case, and the internal organs can be seen between the two mantle edges. The tentacles are fully extended, but as soon as the opening movement of the valves ceases, they are sharply withdrawn, and this is the signal for the closing of the valves. Though the opening of the valves has been a slow, steady movement, they close with a sudden snap. The mantle edges now meet, but leave a space for the water to pass out in front. As the result, the animal is thrown back on to the hinge line with the recoil caused by the water rushing out, and rotating on its axis, turns over.

Now that we have considered the scallop, let us turn to the oyster, a bivalve with which most of us are familiar.



SCALLOP PLACED ON ITS LEFT VALVE.



SCALLOP IN THE ACT OF TURNING OVER SO AS TO RIGHT ITSELF.

Some years ago I spent three days upon an oyster farm, and after the work I saw done there, I came away wondering how it was that oysters were so cheap. On my arrival, I was informed that a great many of the oysters were "white sick," which meant that on opening the valves there exuded from the mantle-cavity a liquid, creamy fluid, which consisted of millions of embryo oysters. At this stage the embryo is devoid of pigment, only partially covered by the primitive shell, and has at one end of it numerous hair-like filaments, known as cilia.

We dredged, and at last brought up a "black sick" oyster, the difference being that the embryos in this specimen were now pigmented, and the two delicate valves completely covered the developing oyster.

Once an oyster is black sick, at any time the young ciliated embryos, known as spat, may be blown out of the mantle-cavity of the parent into the sea. Scrape a slate pencil and drop the dust into a tumbler of water and you see exactly the appearance of the spat to the naked eye when first set free.

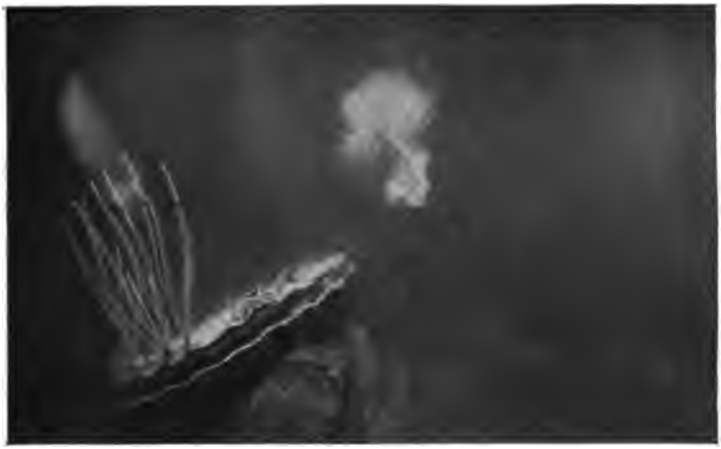
I spent many hours trying to get a photograph of spat being blown out, but did not succeed. However, as the process is exactly similar in appearance to a scallop blowing out a cloud of sperms, of which I have a series of illustrations, I show a scallop instead. In both cases the valves open slightly more than in the resting position, and then shut with a snap, and each time a cloud is shot out, like smoke from a gun.

Examine the spat under a microscope as it escapes from an oyster. Each embryo is seen to be rushing about, helter-skelter, in all directions. Presently you will detect one lying still, and if lying flat you will see only one of the delicate translucent valves; if lying end up, you will see both the valves, which at this time are shaped alike. As you watch one of the stationary spat, a pad-like structure, known as the velum, will protrude between the valves. This velum is covered with cilia (the hair-like filaments already described), and these moving rapidly drive the spat through the water. Watch carefully and you will see a spat come to rest, for as it swims the velum is suddenly pulled in, and the valves closing over it, the spat stops with a jerk.

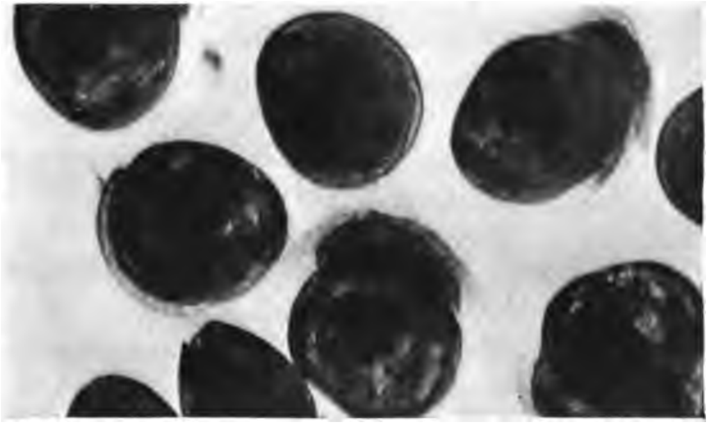
Each oyster expels about three million spat. Imagine the number shed over a large oyster bed!

If within forty-eight hours the spat finds a suitable resting place to which it can become attached, it may ultimately grace a Lord Mayor's banquet. But should it be carried about in the sea by strong tides and rough weather for longer than this period, the spat will perish.

Now, let us study the life of an oyster on a farm. First the beds are thoroughly cleaned of all seaweed, and the "hassack banks" are, as far as possible, destroyed. Hassack banks is the name given to the mounds of mud and debris surrounding colonies of tube-building worms. On the clean oyster bed are put down quantities of bleached oyster shells, technically known as "cultch."



SCALLOP BLOWING SPERMS INTO THE WATER.



OYSTER SPAT.

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The mature oyster spawns about June or July, and the spat escaping as described, settles on the cultch. This is a most critical time for the oyster breeder. If the weather is fine and warm, with the water at a temperature of about 68° F., the spat falls at once, and is retained on the bed, but should it be cold, windy weather, it is carried miles away to perish.

As soon as the spat has become attached, the velum, having done its work in assisting to carry it to a suitable resting place, disappears. The spat, which is considerably less than one hundredth of an inch in diameter when it first escapes, soon commences to grow, and if a cultch shell is carefully examined with a magnifying glass three days after the spawning has commenced, baby oysters can be detected as minute shining specks.

It is not left to chance for the oysters to mature, for their mode of living is henceforth carefully regulated. Every October they are dredged up off the oyster bed, and transferred to pits on the marshes, with the object of protecting them from cold and winter storms. The following March they are placed on the beds again which, in the meantime, have been thoroughly cleansed.

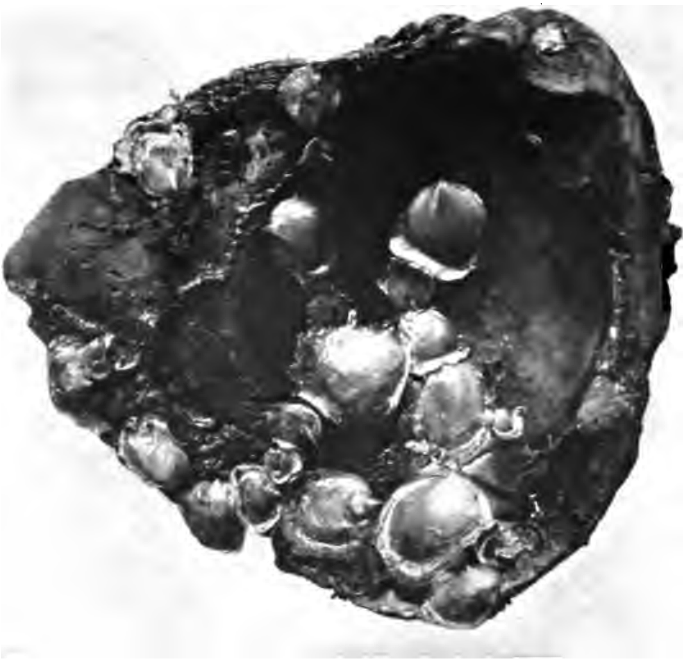
In October of the first year the clean shells put down as cultch, are taken up as " spat shells," and these spat shells, covered with little oysters, go into the pits.

In the spring of the second year the spat shells go back to the beds, and in the autumn are taken up as " bundles of brood." In the third year, when the bundles of brood come out of the pits, the oysters are taken off the large shells, and separated from each other with a knife known as a "culltack." These separate oysters now go on to the beds, to come up in the autumn as "half ware." During the fourth year the half ware of March become the "ware" of October, and in the fifth year the ware taken from the pits and put on the beds, come up in the autumn as "oysters," and are now ready for the market.

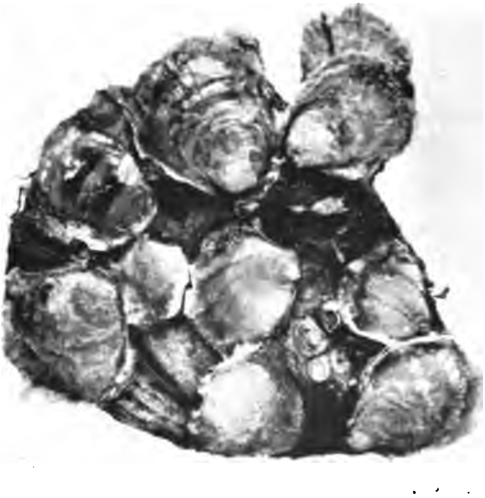
But work as he may, the oyster farmer is liable to meet with disaster at any time, and lose the whole of his harvest.

We have already seen that the spat may die or may not settle on the beds at all, and even if the spat settles, a few days cold may kill the lot; later, shifting sands may smother the young shell-fish, and lastly there are many inhabitants of the sea who appreciate the luscious oyster as much as man, and devour it greedily. Skates, rays, cod-fish, and the octopus take their share, but the worst enemy of the oyster is the "five finger." This star-fish grows to a considerable size, a large specimen being as much as from sixteen to seventeen inches in length from finger tip to finger tip, and a crowd of these ravenous creatures will sometimes swarm over a bed, and destroy it in a single night.

A star-fish extracts an oyster from its shell in a variety of ways. Sometimes he will get directly over the oyster and encircle it in his fingers, then protruding his stomach through his mouth, he engulfs his victim;



SPAT SHELL.



BUNDLES OF BROOD.

the oyster soon sickens and his valves gape open, then the star-fish sucks out the contents and rejects the shell. Occasionally the star-fish arches itself over the oyster, and grasping the two valves with its tube-feet, by a steady pull forces it open.

Constant war is waged against the star-fish, and any brought up in the dredge are thrown into a bucket or other receptacle on board and taken ashore. Here they are collected in a heap and sold as manure. If a star-fish is merely broken up and thrown back into the sea, it does not necessarily follow that he will die, for these creatures are very tenacious of life, and are able to renew parts that have been destroyed.

Another enemy is the whelk (*Buccinum undatum*). This mollusc holds the oyster with his fleshy foot, drills a neat hole right through the hard shell, and then sucks out the contents. This hole is made with a rasp-like band, known as a radula. Radulæ are to be found in the floor of the mouth of many molluscs. In the whelk the radula is armed with about two hundred and fifty teeth. I once saw a whelk surround the end of a dead crayfish with its foot, of which an illustration is shown; later, when the crayfish was picked up, the whelk dropped off, but not before he had partially sawn through the shell. Mussels sometimes do great damage on a bed, not only by harbouring dirt all around them, but by actually growing over and smothering the oyster. The mussel is a favourite food of the star-fish, and so though the star-fish devours oysters, it also helps to keep down the mussels. On a large oyster bed which had become smothered with mussels the experiment was made of importing star-fish. These soon destroyed the mussels, and when all the food on the bed was gone, they departed.

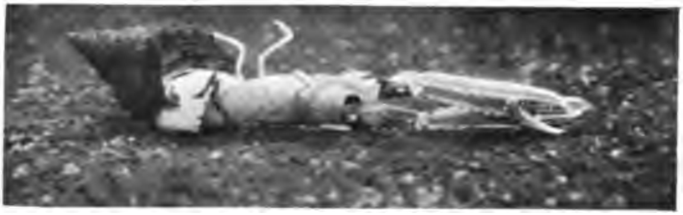
Finally, crabs crack open the young oysters and devour the contents. From all this it will be realised that the oyster must go through many trials and tribulations before the final ordeal of appearing at table.

There are many forms of life in the sea which, though smaller than the star-fish and oyster, well repay the trouble of collecting and observing, such as crab larvæ, various worms, and developing fishes.

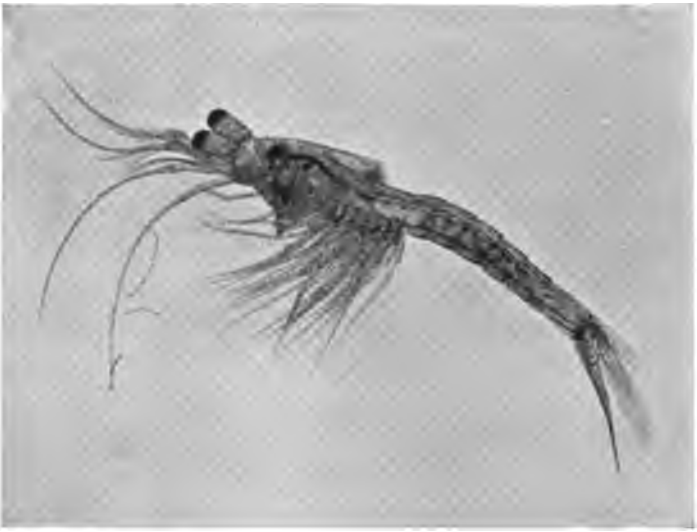
Minute creatures may be obtained in two ways: firstly, by pulling up seaweed, among which will be found quantities of interesting marine life—and this can be done by dragging from a boat a bar of metal armed with several hooks along the sea bottom; secondly, by towing a net through the water.

"Mysis" is one of the interesting crustaceans collected in this manner. This crustacean is peculiar in having two auditory sacs on certain appendages of its body. The auditory sacs are well shown in the photograph and look like two little eyes.

Constant reference has been made to the way in which one creature in the sea preys upon another, but everything must have a beginning, and for the ultimate food of fishes we must look to the microscopic



A WHELK FEEDING ON A CRAYFISH.



A MYSIDACEA (*magnified fifteen times*)

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animal and vegetable life known as protozoa and protophyta, of which diatoms are the most important. Protozoa and protophyta each consist of but a single cell, and are among the lowest forms of life to be found in the sea.

The seal feeds on the cod, the cod on the whiting, the whiting on the sprat, the sprat on the copepod (a minute form of crustacean always present in the sea), and the copepod on protozoa and diatoms.

Again the ray devours the plaice, the plaice devours the worm, and the worm feeds on various low forms of marine life, which exist on diatoms, and so protozoa and diatoms are the ultimate food producers.

How comes it that diatoms can meet the immense demands that must be made upon them, since each of these consist of but a single vegetable cell, not the size of a pin's head ? It has been calculated that a diatom, dividing in two, as it usually does five times in a day, would at the end of a month, if no destruction occurred, form a mass a million times as big as the sun.

Thus we see that diatoms and other microscopic plants constitute the pastures of the sea upon which everything, including man, ultimately feeds.

Now life in the sea may be conveniently divided into three great divisions. Firstly, fishes and some crustaceans which roam from end to end of the ocean ; secondly, the life which lives on the bottom, such as the sea-weeds, sponges, shell-fishes, star-fishes, and the fish that are of sedentary habits ; and, lastly, the life which is carried hither and thither by tides and currents, and is to be found in every ounce of sea water. To this third form of life is applied the term "plankton," and of this plankton, diatoms constitute one of the most important elements.

The reason why men of exceptional marine biological knowledge and ability, such as Henson and Herdman, have devoted, and are devoting, so much of their time to the study of plankton, is because everything ultimately depends upon it, and in order to understand the conditions most favourable to fish life, it is necessary first to have a thorough knowledge of plankton.

Plankton consists, firstly, of those minute creatures which spend their whole existence drifting about in the sea, as for example, the copepod, and the lowest forms of animal and vegetable life, such as protozoa, infusoria, and diatoms; and, secondly, of what is known as "transitory plankton."

The latter mainly consists of the larvæ of various marine animals which pass only the early part of their existence drifting in the sea, but in adult life settle on the bottom, or roam the ocean.

The spat of the oyster already mentioned, while it drifts about, is transitory plankton. Likewise the minute larvæ of crabs, lobsters, mussels, whelks, starfishes, urchins and many others. All these larvæ are entirely different in shape and appearance from the ultimate form which they will take in adult life, and most of them are ciliated, like the oyster spat. To transitory plankton must be added the myriads of floating eggs and helpless larvæ of marine fishes.

Transitory plankton, as will be seen later, materially adds to the food supply in the sea, and, further, the fact of its drifting about has an important bearing on the distribution of various forms of marine life. As the seeds of plants and trees on the land are carried hither and thither by the wind, so similarly the larvæ of marine animals are carried through the ocean by tides and currents. In this manner marine life is maintained in more or less the same proportions all over the world, whatever may be the agencies working for its destruction.

As the pastures of the land die down in winter, and life lies dormant, so in the sea plankton dies down; but the sea is never altogether sterile, for copepods are always present, as well as many other varieties of small crustaceans.

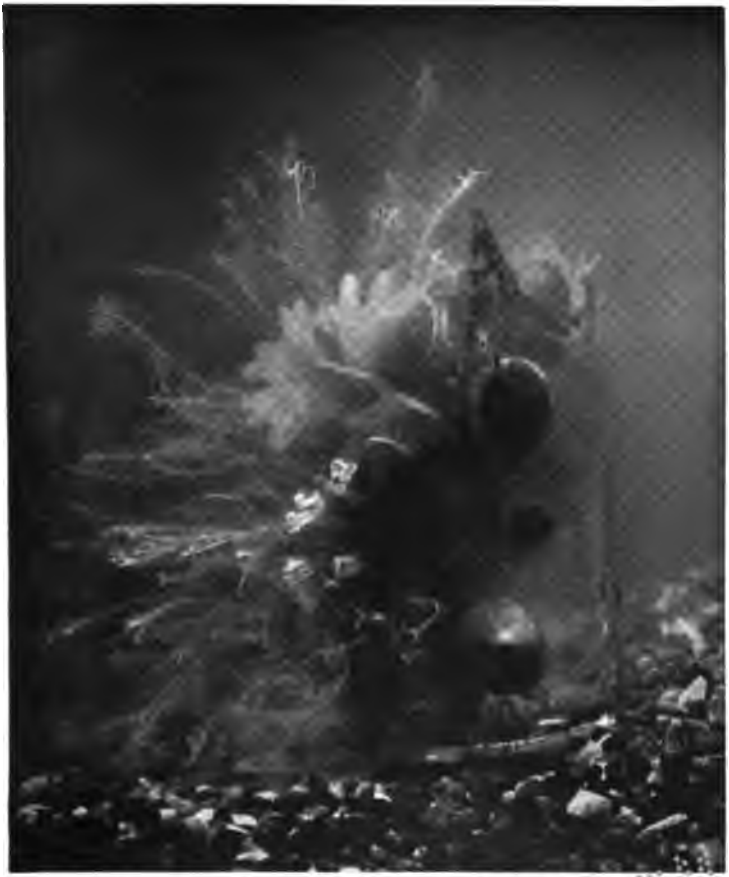
With the advent of spring, the sea is flooded with the eggs of spring-spawning fish, such as the plaice, the haddock and the cod, and these very soon hatch into the various larval forms. Simultaneously the minutest forms of plankton life (protozoa and diatoms) increase in the miraculous manner described; while the larvæ of the barnacles, sea-squirts, crabs and copepods appear in their myriads. In June, July and August the sea is full of the eggs and larvæ of summer-spawning fishes, such as the ling, the mackerel, the turbot, and the sole. The diatoms have now eased off and though the crab and barnacle larvæ still remain (in a somewhat altered form), the larvæ of star-fishes, urchins, and numerous others are now added to the sea.

Thus it will be seen that in the spring and autumn the sea is a mass of minute animal and vegetable life.

In the spring the larval fish mainly feed upon the diatoms, and later on in the year to a great extent upon the larvæ of various marine animals.

The smaller forms of plankton life can only be collected in a net with a very fine mesh, but if any of my readers are anxious to examine plankton under the microscope, it is not difficult to make a net of No. 20 bolting cloth, which can be purchased from flour milling engineers. When at the seaside such a net slowly towed behind a boat, will bring up many quaint forms of life, but at times the main catch may be almost entirely a large round protozoan, about a twenty-fifth of an inch in diameter, known as noctiluca; this, when seen for the first time, may be mistaken for a fish's egg. The phosphorescence in the sea on a summer's night is due to these protozoa. If a spoonful or two of the noctiluca be collected as described and spread out on a piece of blotting paper, it is quite easy to read by the light given off from them. Noctiluca, like diatoms, at certain seasons increase with miraculous rapidity, and by daylight may cause the sea to appear of a reddish-brown colour.

As the water in the sea swarms with plankton, so the bottom of the sea is carpeted with teeming life;



BROKEN BOTTLE FROM THE BOTTOM OF THE SEA.

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for besides the animals that crawl about, every rock, stone and weed is covered with hydroids, sponges and barnacles, and often the rocks themselves are riddled by boring creatures. Even the empty tin or broken bottle thrown over the side of the boat, is soon covered both inside and outside with various forms of marine animals. As an example, look at the illustration of the portion of a broken bottle dredged up outside Plymouth. To it are attached bunches of feathery hydroids, various shell-fish, sponges and masses of ova. Had the hydroids and ova been undisturbed, from the life on this bottle alone many thousands of individuals would have been added to the plankton of the sea.

CHAPTER IX

FISH PHOTOGRAPHIC EXCURSIONS

OCCASIONALLY photographs of fish life can be procured which do not entail much trouble or expenditure of time. This, however, is a very exceptional occurrence, and in consequence, with the individual whose time is not his own, fish photography on an extensive scale can only be undertaken during a holiday.

Ten years ago I went for my first fish photographic excursion to the Norfolk Broads in order to study and photograph bream, roach, rudd, carp, and perch. I availed myself of a long-standing invitation to stay at a quiet country rectory. On my arrival at a wayside station on the Great Eastern Railway I was met by the whole family, and the gardener's boy with the wheelbarrow for my luggage. My friends had not realised that fish photography entailed a certain amount of paraphernalia, and expressed their surprise at the amount of my kit. Certainly it did make a somewhat imposing heap as it was turned out on to the platform. Successful fish photography, however, is impossible without a fair amount of apparatus. Mine consisted of two glass tanks, a flat wooden tank for storing fish, two wooden trestles, four eleven-inch boards (each six feet in length), two fish cans, a rod box, a trunk containing photographic material, a plain canvas background, sixty feet of garden hose, and my ordinary luggage.

We soon borrowed a cart from a farm near by, and conveyed this miscellaneous collection to the rectory.

Fortunately, my friends were quite interested in the idea of photographing fish, and immediately after tea the whole household assisted to get things ship-shape. The tanks were set up in the stable-yard; a constant supply of running water was ensured by connecting up the garden hose with the cistern, and the pantry was converted into an excellent dark-room.

By 4 a.m. on the following morning the son of the house and I were fishing on Fritton Decoy.

Fritton is at all times a beautiful lake, but on that still summer morning it appeared a fairyland, for the sun, as it topped the woods around, caught the banks of light-coloured reeds which skirt the shores of the lake, while the golden reeds and the dark firs beyond were reflected on the glassy surface of the green water.

After two or three hours' fishing we had caught white bream, perch, and ruffe. By this time the world was astir, so, rowing ashore, we hired a cart from a public-house near by, and drove home with three or four specimens in each fish can.

I would here mention the importance of never crowding fish together. The can should not be more than half full of water, and the more it splashes about, the better, for this helps to aerate it and keeps the fish healthy.

As stated, the tanks had been arranged in the stable-yard the night before. This arrangement consisted in the trestles being placed about six feet apart, and the boards laid upon them so as to make a platform. One tank was placed on the edge of this platform, and the second tank immediately behind it.

These tanks are three feet long, two feet high, and eight inches and one foot respectively front to back. The bottom and the sides consist of wood; the front and back of quarter-inch plate glass. Half-way down one side is an inlet tap (to which is attached the hose), and two inches from the top of the other side is an outlet pipe.

The narrower of the two tanks is placed to the front of the platform, and the hose connected to the inlet tap. The bottom of this tank is next covered with stones, gravel, sand, earth, dead leaves, or weeds, according to the kind of fish to be photographed. As soon as the tank is full of water, the fish showing the most typical shape is placed in it. At first he rushes about and stirs up the dirt, but soon settles down to sulk on the bottom. From now onwards a steady stream of water is kept flowing through the tank. The rest of the fish placed in the flat, box-like wooden tank are also kept in running water by connecting up the outlet pipe of the glass tank with the wooden tank. The safety of the fish being ensured, it is now possible to spare a few minutes for breakfast.

After breakfast the second tank is prepared. This tank is placed immediately behind the other, and in it are arranged suitable weeds (gathered during the early morning fishing excursion). No water runs through this tank, and at first it is thick and muddy, and the weeds droop. On the platform behind the second tank are placed stones, gravel, earth, sods of growing grass, or stiff reeds. Beyond is hung up the plain canvas background. When the sun is low and casts a long shadow, this background must be sufficiently far back to be out of the shadows of the tanks.

The preparation of the second tank and platform has probably occupied an hour or more.

Now leave the tanks for two or three hours. After lunch go back, and the change is wonderful! The water in the front tank is crystal clear. Possibly the fish may be swimming about, but more probably it is still sulking on the bottom. The water in the second tank has cleared considerably, the weeds have freshened up, and every leaf is covered with bubbles of gas; and the earth, stones, and clumps of reeds on the platform behind the tanks (seen through the thickened water in the second tank) all appear to be part of a pond scene.

The water in the second tank ought to be just sufficiently thick to obscure the farthest edge of the platform as seen on the ground glass when the fish in the first tank is sharp in focus. If the water in this tank is too thick, run a stream through it for a few minutes with the hose pipe. If too clear, stir up the bottom with a stick. In a photograph the thickened water in the second tank is invaluable from a pictorial point of view, for it gives the picture its watery appearance.

Care must be taken to arrange the tanks so that when the photograph is taken the glass of the tanks is at right angles to the direction of the sunlight.

If the sun is shining, photography of the specimen placed in the front tank may be proceeded with at once. But if the sun is not shining, it is far better to postpone operations until the following day, or until the sun does shine. The reason for this is that with a dull light and thickened water in the second tank the image of the photographer and the camera are reflected in the glass. Further, it is difficult to get sufficient exposure with a rapidly swimming fish, except in sunlight.

Presuming that the sun is shining and the scenic portion of the picture has been arranged to complete satisfaction, all that remains for consideration is the fish. Possibly it may be swimming about, and, if so, nothing further is required; but more probably the specimen is still sulking on the bottom. To induce the fish to swim, the water should be stopped from running through the tank, and after ten minutes suddenly turned on at full force. This will frequently stir up the fish, and he will swim round, heading towards the stream, thus giving the photographer an opportunity to obtain a snap-shot. As an example of a photograph obtained in this manner, I would refer the reader to the illustration of a sea-trout, facing page 82.

On this particular excursion I was most fortunate in obtaining fish and good weather in which to photograph them. But it is unwise to upset a household with fish photography for more than a fortnight at a time, however kind your host, and so I moved on to Acle, a village on the River Bure.

Sending home all my tackle except one tank, some short lengths of hose, and the fish-cans, I took up my quarters at the hotel.

Frequently it is not possible to take all the gear for tank photography, and the method of working with a single tank is as follows: Place the tank on a box or table, fix up a white sheet ten or twelve feet behind it, and photograph the fish in clear water without any stones or weeds in the tank. The white sheet should be sufficiently far behind the tank to be quite out of focus, and then no creases will show. A print from a negative obtained in this manner will show the fish against a perfectly clear background. When dealing with photography "at home," I will describe how a suitable scene is photographed to fit this fish, and the two negatives used to make a combination print.

At Acle I found four anglers who had taken up their quarters at the hotel with a two-fold object: one of having a good time, and the other of attempting to catch fish. These four fishermen came down to breakfast on the first morning after my arrival to find me at work in the back yard. At first I was considered a lunatic, but when they found that I enjoyed life the same as they did, and that I knew almost as much about fish as any of them, we became the best of friends, and they all worked hard to catch specimen fish, with varying success. One of them, however, did catch a perch which was estimated to weigh at least two pounds. Putting the fish into one of my cans, he at once started to walk to the hotel. On his way, however, he passed two of his friends fishing from a boat, and, proud of his catch, he came to the river-bank and lifted the perch out of the can. Immediately the fish erected his first dorsal fin, and the sharp spines ran into the fisherman's hand. Uttering an expression suitable to the occasion, he dropped the fish, and the perch, after two or three flops on the land, escaped into the water. It is quite probable that my friend really did catch a perch, for his hand was considerably torn, and I do not think he knew enough about fish to tell me that a wound of that sort had been given him by a perch if such had not been the case.

Fish photographic excursions, like all others, sometimes go wrong. It is now two or three years ago that I went to the Hebrides to combine sea-trout fishing and photography. When I arrived at Tarbert I found that the whole of my kit had gone on to Stornoway. Excitable Southerner as I am, I was telling the boat officials what I thought of their carelessness, when a bystander remarked to me: "Och aye, it's aften that veesitors' luggage will be going to Stornoway; maybe it will return next week, but verra likely it will be going on to Glasgae, where ye'll be finding it at MacBrayne's office on your way back!"

I left five shillings to cover any expenses which might be incurred in recovering my luggage, and in four days it turned up.

In the meantime I watched a sea-otter kill three salmon, caught two myself (with borrowed tackle) on the hotel waters, got wet through every day, and had to wear the hardy landlord's underclothing, which to my pampered skin appeared to be made of horsehair and heather, and finally had an opportunity of realising what a whaling station is like on a hot August afternoon.

Previous to my arrival the weather had been fine, and the water was low, so I started out to catch sea-trout with a ten-foot rod, a fine line, nine feet of drawn gut, and a small, bright-coloured fly. But on the second day, as I was fishing, the sky clouded over and a gale of wind got up which churned the loch into a miniature sea. Suddenly I was into a big fish. This turned out to be a clean run, seven-pound salmon. Sandy, my gillie, was seventy years of age, consumptive, and had a weak heart, and yet the old man worked the boat so well that we killed the fish—a feat that with my light tackle in such a gale of wind would have been impossible except for his skill.

We landed, and ten minutes were allowed in which to drink the health of his majesty the salmon and enable Sandy to recover from his exertions. Then back on the water, and within three casts I was into another fish, which ultimately turned the scale at eight pounds. Sandy worked the boat with the same consummate skill, and enabled me to kill a seven and an eight pound, clean-run salmon on extremely light tackle. When we came to shore with the second fish the old man was dead beat, and so we gave up fishing for the day; but nothing would satisfy him but to let him carry these two fish back to the hotel himself, five miles over an Hebridian road. Arrived at the hotel, Sandy required a considerable amount of reviving; but Sandy was a Scotsman!

A few days after this was the Sabbath, and so after breakfast a friend and I started on what turned out to be a most entertaining walk. First we went down to the creek, into which the water from the hotel lochs emptied. While lazily lying on the shore I detected a sea-otter at work just across the bay, a distance of some two or three hundred yards. Viewed through field-glasses, we could see him watching the salmon crowded in the water below him; then he quietly dropped down off a rock into the sea, and in a few seconds came up with his teeth through the shoulders of a struggling fish. Three times did we see that otter dive down into the water and bring up a salmon each time. He appeared to kill the fish and then leave them on the bank. My friend and I walked back to a fisherman's hut near by, to get him to row us over the bay, but it was the Sabbath, and the fisherman refused to go. I was particularly anxious to see the fish, and so trudged three miles to cross the river at a ford. When I got to where the salmon had been killed the fish were gone, and a boat had recently been pulled on the shore!

My friend and I now turned inland and trespassed on an extensive deer forest until we lost our way. But near Tarbert, where I stayed, there was a whaling station, and if a south wind was blowing there was no fear of one's bones bleaching on the bleak hill-side, for it was always possible to smell one's way to the shore—and this is what we did.

Arrived at the station, we knocked at the door of the manager's house, and a bearded Norwegian, six feet six inches in height, demanded in gruff tones our business; but the forbidding appearance and the gruff voice were merely a warning to trespassers, and masked (as we found later) a most genial host.

We were informed that the midday meal was at two o'clock, and if we cared to wait till then we were welcome. As soon as we got in we were told to take off our boots and were laid in bunks while our host slumbered on a sofa.

Have you ever tried to sleep at a whaling station in a wooden hut on an August afternoon, with the temperature about 90° Fahrenheit, amidst thousands of buzzing flies, and choked by a stench of decomposing whale? But our inability to sleep was merely due to the novelty of our surroundings, for our kind-hearted host slept soundly on the sofa, snored like a fog-horn, and woke thoroughly refreshed for his meal. We started on excellent coffee, and then followed a royal repast which was most welcome after our long walk—soup with some body in it, followed by suet, mutton, sago pudding, cheese, and finishing up with cake, rye whisky, and strong cigars. Fortified in this manner, we ventured to inspect the station.

Five large whales were lying in the bay, and in consequence of the heat suggested inflated balloons. All around thousands of gulls were screeching and skirling, as they fought over the offal. Without these scavengers it is difficult to imagine what a whaling station would be like! We saw the cranes by which the whales were hoisted out of the water on to a large wooden platform. Here they were cut up. The flesh was then boiled down in huge cauldrons, ultimately to be converted into cake-food for cattle, and the bones were used for artificial manure.

On this station there were two whaling boats—steamers some ninety feet in length. In the bows of each boat was a swivel gun from which could be shot a harpoon. The whales were met with from fifty to one hundred miles outside the island of St. Kilda. Each of the boats was away about a week, at the end of which time it returned to the station, towing a string of five or six whales. It was a very interesting afternoon, but for the three following days the guests at the hotel were aware of the fact that we had paid a visit to the whaling station!

Next year, instead of going to the Hebrides, I went to Cornwall, and here I had numerous opportunities for photographing some of our commoner food fishes. During this particular trip my brother and I did a certain amount of sea-bird photography, and we photographed one particular common gull from the time it hatched until it left the ledge of rock upon which the nest had been built. It was a pretty sight to see the young bird peering over the edge of the cliff into the sea below, wondering how long it would be before he could fish for himself.

My next photographic holiday was spent at Port Erin, and to this place, in addition to the tanks already described, I took a large tank which, as a rule, I only use at home. And here I would give a word of warning to those using large glass tanks in hot weather. This tank, which held several hundredweight of water, was set up just behind the biological station. Here the sun blazed upon the glass, while the cold sea-water from a large storage tank ran through it to the plaice ponds beyond. My brother and I had been working in front of this tank all the morning, and had only just left to go home to lunch. When not a hundred yards from the station we heard a terrific bang, and running back found that the tank had burst, and that huge pieces of half-inch plate glass had been thrown a distance of forty feet. The plate glass had burst in consequence of unequal expansion of the glass, due to the cold water on the one side and the intense heat of the sun on the other. It was a narrow escape, and on the few occasions that I have used this tank since, I have always kept the glass shaded until actually wanted for photography.

To those likely to go on fish photographic excursions I would strongly recommend them to confine their attentions to the West Coast. Here the water is much clearer than on the East Coast, and renders photography, both in tanks and in natural environments, an easier matter.

Hitherto I have confined my remarks to tank photography alone, but far more fascinating is the photography of fish in their natural environments. It is possible to undertake this in various ways. The reader may don a diver's suit, as did Dr. Bouton, of Paris, and descend into the sea with the camera encased in a water-tight box; or sink a camera with a fixed focus into the water, and expose the plate by pulling a string. Professor Reighard, of Michelin, wades into the water with a reflex camera merged below the surface. These methods, however, do not appear to have given very satisfactory photographic results, for the simple reason that it is necessary to be within a few feet of a fish to photograph him under the water, and the operator not being concealed, the fish do not stay to be photographed. It certainly might be possible to descend in a diving-suit, and conceal oneself in the water, as the Keartons conceal themselves on land; but even then the scope of sub-aquatic photography would be greatly limited by the question of light.

As the nearest approach to fish photography in natural environments, I have referred, in the introduction, to the use of a specially constructed pond.

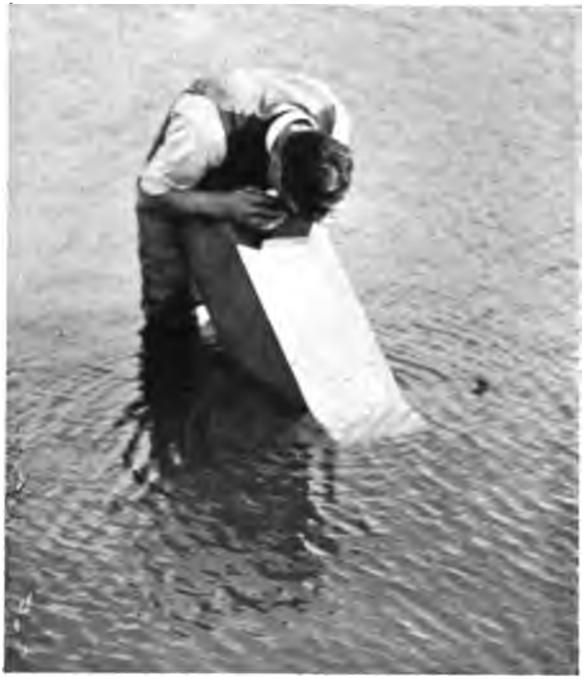
Fish photography can also be undertaken with the camera above the water; but as the object of such work is essentially to see fish as they appear to each other, this bird's-eye view of fishes is only interesting in the case of those which live near or on the bottom.

The difficulty in this form of photography lies in the fact that the light reflected by the surface of the water obscures the fish and fogs the plate. Every angler will have noticed that even in a clear, smooth-running stream, very little can be seen below the surface, except where a tree overhangs the banks. The tree cuts off the light from above and the weeds, stones, and fish beneath the water become visible. In the same manner every pebble on the bottom under a bridge can be counted.

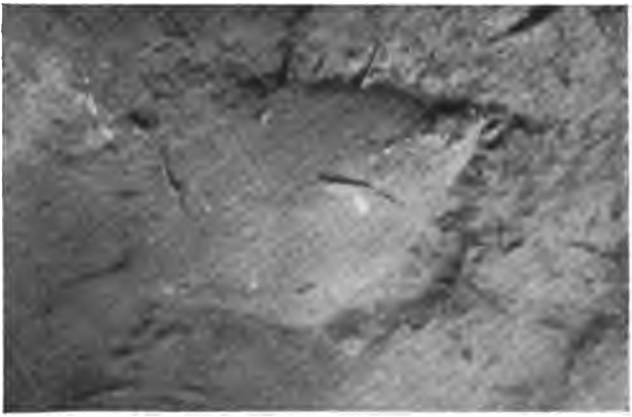
Under certain conditions, even when the light from above is not cut off, the observer is able to concentrate his attention upon the fish and ignore the light reflected from the surface. The camera cannot do this, and the greater amount of light reflected from the surface fogs the plate before the lesser amount of light reflected from the body of the fish can make any impression upon it. Therefore, when using the camera above the surface of the water it is necessary to use some form of apparatus which cuts off the light from above. With this object I use three different contrivances: (1) A light wooden frame, six feet by four, over which is stretched a sheet of dark-coloured canvas; (2) a large golf umbrella; and (3) a special apparatus on the principle of a sea telescope. The method of using the frame is to fix it at an angle to the surface of the water, facing the sun. Thus the light is cut off from above, and if the shield points directly towards the sun, only a narrow shadow is thrown at its base. The sunlight, penetrating the water at an angle, illuminates every pebble. In this manner a photograph of a swimming fish can be taken at an exposure of $\frac{1}{50}$th of a second below three feet of water.

When it is desired to take a photograph looking directly down on a fish, the second method is available. In this case the light from above is cut off by holding a large umbrella above the head of the photographer. The illustration of a young thornback ray, facing page 44, was obtained in this manner.

These two devices, however, can only be employed when the surface of the water is unbroken. When that condition prevails resort is made to my third device, which is illustrated on the plate facing this page. This apparatus was constructed with the two-fold object of cutting off the light from above and of getting below



METHOD OF PHOTOGRAPHING WITH THE CAMERA ABOVE THE WATER.



PLAICE PARTIALLY BURIED IN MUD AND SAND.

the disturbed surface of the water. It consists of a box, three feet long and one foot square, fitted with a ¼-plate reflex camera. The camera slides up and down inside the tube, and can be fixed at any desired point.

In constructing this apparatus, my original intention was to use it for taking colour photographs of marine animals in pools among the rocks. I closed the end of the tube with a sheet of plate glass, and intended to push it right down, so as to have only a few inches of water between the anemone, sponge, or crab, and the camera. The first time I used it I succeeded, with difficulty, in getting it about half-way beneath the surface of the water, when suddenly it tilted to one side. I slipped and sat on the bottom of the pool, the tube filled up, and the camera was soaked.

The experience gained resulted in the construction of quite a useful apparatus. The plate glass was taken out from the end and fixed six inches up the tube, and the whole apparatus shortened. When in use, the end of the tube is now a few inches under the surface, and the weight being supported by the water, it can readily be turned in any direction.

The lower illustration facing page 172 shows a plaice photographed by means of this apparatus. This fish, when disturbed, swam off, but revealed the place where it stopped, by raising a cloud of mud, as it attempted to bury itself on the bottom. The photograph shows how, when the disturbed mud settled, it assisted to conceal the fish.

I have often attempted to photograph the fish in a public aquarium, but have found that it is practically impossible to avoid the reflection of the tanks. In aquaria with a good top light a sheet can be attached to the top of the tank and carried over the photographer, as shown in the second plate facing page 24. In this manner not only is the reflection avoided, but the fish are seen illuminated as in Nature. In most aquaria, however, there is insufficient light for photography of moving objects.

CHAPTER X

FISH PHOTOGRAPHY AT HOME

AFTER a fish photographic holiday, I usually return home with a hundred or more negatives. Some of these are of fish in natural environments; others show them swimming amongst weeds, which have been arranged in a tank; but a considerable number of the negatives are of fish seen against a white background, the last being taken in clear water in front of a white sheet, as described in the preceding chapter.

As a record of shape and external appearance, this is all that is required; but to show a fish swimming, as it were in mid-air, looks unnatural, and fails to interest most people. Therefore, without in any way diminishing the value of the negative as a record, on my return home I print in a suitable aquatic scene round the fish.

As the landscape photographer collects cloud negatives, so at odd times I have collected negatives depicting scenes under the water. Recently I have obtained these in the pond; but as everybody cannot have a pond specially constructed for photography, I will explain how I used to obtain them in a tank, and then describe how the fish negative and the scenic negative are combined to make a single print or lantern slide.

Two tanks are placed on the wooden platform already mentioned, and stones and weeds are arranged in both the tanks and on the platform. The water in the front tank is next stirred up so that everything is obscured. By the time this water has partially cleared, the weeds (which when first put in were limp and drooping) have freshened up. As soon as the water has cleared sufficiently to show the weeds in the front tank, the first photograph should be taken. A second should be taken when the weeds in the tank behind it are also showing, and a third exposure made when the weeds in both tanks and the stones on the platform are visible. In this manner three scenic negatives can be obtained from a single tank arrangement.

If a dark background is required in order to show up a silvery fish, the canvas screen behind the platform should be thrown into shade by tacking a sheet from the top of the canvas background to the top of the tank.

The method of combining a fish negative and a scenic negative together so as to make a single print is as follows :—

First make a transparency of the fish negative. This transparency will show the fish on clear glass. Next carefully block out the whole of the fish with colour on the film side of the transparency. Then take the scenic negative and put it in a printing frame; against the film side of this negative place the glass side of the fish transparency, and finally against the film side of the fish transparency (in contact with the fish that has been blocked out) place the film side of an unexposed plate. Now give a full exposure and obtain a somewhat muddy transparency of the scenic negative. This transparency will have a clear glass space upon it, which corresponds with the blocked-out fish on the fish transparency.

Wash the colour off the fish transparency, and as soon as the two transparencies are dry, bind them together, accurately fitting the fish on the fish transparency with the clear space on the scenic transparency. When bound together, place them in a lantern and make a single negative, combining the fish with a suitable aquatic scene.

The photographs of the members of the salmon family on the plate facing p. 46 may be taken as examples of combining a fish with a suitable scene so as to make a single print. The smelt was photographed on the East Coast, the rainbow on a fish farm, the brown trout in Scotland; the scenes in which they appear were taken at home.

The above may sound a complicated method of obtaining fish photographs in a tank, but in reality it is much the simplest, the most economical, and usually gives the best results. In order to understand the reason for this, I shall have briefly to refer to the question of reflection in fish photography.

I have already discussed the subject of reflection from the surface of the water when an attempt is made to photograph a fish in natural environments with the camera above water. In tank work when the sun is shining and a tank of clear water is seen against the white sheet, there is no reflection from the glass of the tank, and the photographer can work right in front of it. But when the sun is not shining, or if the water in the tank, or tanks, is thickened, or the canvas screen behind darkened, the glass of the tank reflects the operator, his camera, and whatever happens to be behind him. The photographer has now to stand to one side, and it may be necessary to hang up a white sheet a few yards in front of the tank, to cut off the reflection of the trees and houses around.

It will thus be seen that reflection is a constant source of trouble, except when clear water and a white background are used. To catch the fish in a good position is quite difficult enough without having to dodge reflection. Further, if a fish is taken against a white background, it matters not on what part of the plate it is caught, for it is easy enough to print it in on the most suitable part of the scenic negative. Lastly, when the fish and the scenic portion of the negative are taken at the same time, it frequently occurs that an attitude which one wished to record does not show up satisfactorily in consequence of the fish being mixed up with the weeds.

When away from home, I have devoted a considerable amount of time to recording various types of fish; but at home I have usually taken one fish at a time, and photographed it in various attitudes, or its movements and methods of feeding. This is not altogether an easy matter in a tank. First, the fish must be procured, then he must be kept in the tank under as favourable conditions as possible, in order that he may become "at home" in his unusual surroundings before any attempt is made to photograph him.

As an example of how to go to work to illustrate the attitudes and habits of fish by photography when working with a tank, I will explain how I obtained the three photographs of a perch facing p. 6 and the photographs of the nesting of the stickleback.

The perch is a sulky fish and difficult to photograph, and for the first two or three years the results I obtained were very poor, because I tried to photograph the fish before he had settled down in the tank. About three years ago I constructed a tank on the same principles as those described, but of much larger size. In this I planted reeds, and allowed them to grow. On a platform behind this tank I also grew reeds in tins holding water. The glass of the tank was cleaned daily on the inside to prevent it becoming green. Into this large tank I turned a perch weighing just under half a pound. Water ran through this tank night and day, and the glass was shaded from the sun except when it was removed two or three times a day, so as to get the fish accustomed to being suddenly surrounded by bright light.

At the end of a week I put some minnows in the tank; but the perch would not take these and so they were removed. The minnows were offered to the perch every day during the next week with the same result. At the end of a fortnight the perch took a minnow, and after that he fed fairly freely. He then became comparatively tame, and I obtained several photographs, three of which are shown.

My reason for removing the food unless the fish took it was that the perch would have become accustomed to wait until he was left alone before he fed, and I should never have had an opportunity of obtaining photographs illustrating many interesting attitudes which are connected with the feeding of a fish.

When a fish refuses to feed for a considerable time I turn him free and start again with a fresh one, for fish vary very much in temperament. One will be perfectly tame in a tank in a month or six weeks, whereas another will never get accustomed to such surroundings, and in consequence he does not feed, and will die of starvation unless released.

The photographs illustrating the nesting of the sticklebacks were only obtained after three years' work, for the fish, though they nested, would never do so in a position where it was possible to take a photograph.

The tank in which these illustrations were obtained was arranged in much the same manner as that already described. Above the tank was placed a large bucket which was filled up two or three times a day with water containing thousands of cyclops, daphnia, and other minute fresh-water crustaceans, and the water from this bucket was allowed to flow slowly through the tank. As this form of food is most useful for feeding all sorts of small fish in aquaria, I will describe a simple method of obtaining it.

Procure two or three large tubs, and on the bottom of each place six inches of straw and manure. On the top of this can be planted a few water-weeds to make the tubs artistic.

Next procure a wide-mouthed bottle and a glass funnel which will go into the bottle. Over the mouth of the funnel tie a piece of very fine muslin, and to the other end of the funnel attach about a foot of india-rubber tubing. Now go to the nearest ditch or stagnant pond, and, using a pail, fill up the bottle with water, put the funnel into the water in the bottle, and start a syphon action by means of the rubber tubing. As the water is syphoned out of the bottle, keep on replacing it with water from the pond. In this manner gallons of water pass through the bottle, but the fresh water crustaeeans are prevented from escaping by the muslin stretched over the mouth of the funnel. Very soon the bottom of the bottle contains thousands of cyclops, daphnia, water-beetles, spiders, etc. The contents of this bottle are then emptied into the tubs.

These minute creatures multiply so rapidly that in a week or two the water in all the tubs is seething with life. When wanted for fish food, these crustaceans are collected in a similar manner from the tubs, the water that passes through the bottle being allowed to run back into the tubs.

While on a fish photographic excursion the photographer will have the time and opportunity to procure his own specimens, but should he not be a sufficiently expert fisherman to do this for himself, it is always possible to get specimens from other anglers, or from the professional fisherman, provided he is willing to carry them home in a can. If, however, he should ask a fisherman to get the specimens, he should be sure to mention the largest number of fish that he desires to be put in the can, for the fisherman, as a rule, stuffs the can so full that frequently the specimens are all dead before they reach you. I well remember lending a large can to a shrimp trawler in order to procure a number of small flat fish. It came back two-thirds fish and one-third water, there being some three hundred specimens in all, and not a living fish among them!

The procuring of specimens for photography at home is a much more difficult matter. My living fish have been obtained in various ways.

In the first place, many beautiful specimens have been brought to me from time to time by members of the local angling societies, and as I am fairly well known to the professional fishermen, odd specimens of sea-fish are occasionally brought up to my house. Recently in this manner I received the largest lump-sucker that I have ever seen. This fish is one of the ugliest of our sea-fishes, and is known as a sucker because the pelvic fins are modified to form a cup-shaped sucking disc. By means of this disc the fish attaches itself to the rocks. The pelvic fins forming the disc are very much thickened, and are fleshy round their edges, and the sucking action is caused by the contraction of the muscles of the fins which flatten this disc on to the rocks. Lump-suckers' eggs are often to be found round our shores, and on one occasion a fisherman brought me a tin upon which masses of these eggs were attached. These duly hatched, and I was able to photograph the growth of the young lump-sucker.

While writing about the parental care of fish for their eggs and offspring, I might have mentioned the lump-sucker, for the persistence with which the male guards the eggs is exceptional. McIntosh quotes a case where a lump-sucker had attached the eggs to a stone just above low-water mark; the stone, however, was partially covered at low tide, as it was situated in a run of water. With every low tide the body of this fish was only partially covered, and its gills were half out of water; and though the June sun made him pant, and the fish must have been thoroughly uncomfortable, this devoted parent never deserted the eggs.

To test this parental instinct the fish was removed a couple of yards, but at once wriggled back to the former position, with its snout almost touching the stone to which the eggs were attached.

To return to the question of procuring specimens for photography. I find my friends do not always choose the most convenient time for bringing them to me. For example, an angling friend of mine was cleaning out a ditch near the banks of the Orwell, and saw a large fish moving in the mud; being an enthusiast, he at once jumped in and seized it. Orwell mud is black, sticky, and odoriferous, and there was quite a crowd of little boys when my friend presented himself at my consulting rooms, dripping wet, covered with black mud, and carrying a small wooden bucket, in which he was endeavouring to keep a huge lamprey.

On a few occasions I have photographed fish that have been sent to the taxidermist to be set up. For example, the tench shown on the plate facing p. 80 was one of two fish taken out of the mud while a pond (not many miles from Ipswich) was being cleaned. These fish were wrapped in a damp cloth, and sent by carrier to the taxidermist. Here they soon recovered in a tub of water, and next morning I got some excellent photographs. The two tench were exceptionally fine specimens, weighing over three pounds apiece; and I am patiently waiting for the day when the owner of the case proudly shows me these tench, for I shall then be able to offer him a photograph of them, taken when alive, and twenty-four hours after they were fished out of the mud.

Finally, my friend Mr. Richmond has from time to time sent me Loch Levens, rainbows, Windermere char, and good specimens of commoner fish.

When a fish arrives from a fish farm it has travelled in a large can constructed for the purpose, and is probably quite fit. But often a fish brought by a friend is half dead, for though many people can catch fish, few know how to keep them alive.

The first thing, then, is to revive the fish. Let the cold water tap run with full force into the bath, and hold the fish two or three inches under the water, with the bubbles of air rising all round its snout. If this is insufficient to revive the fish, pour a little weak whisky and water down its mouth, or swab the gills with cotton wool dipped in the same restorative. A fish is never beyond hope until it is stiff.

Once revived, place the fish under conditions to ensure its convalescence. This is best done by keeping him in shallow water, the surface of which is being continually disturbed; fish will keep healthy during long periods in water so shallow that their back fins appear above the surface, whereas they will die in a bucket full up to the brim. The reason for this is that in shallow water a large surface in proportion to its bulk is exposed to the air, and in consequence the water takes up more oxygen. Further, if the water is so shallow that the fish disturbs the surface as he swims about, the absorption of oxygen from the air is materially assisted. Personally, I keep fish in a tank with water splashing on to the surface from a considerable height, for at home my fish photography is uncertain, and it is often a week or more before I can attend to the specimen.

In passing, let me refer to the keeping of fish in bowls and small aquaria. I do not believe anybody is intentionally callous to the sufferings of beasts, bird, or fish. But in our ignorance there is no doubt we inflict much unnecessary pain on our pets. Fish in natural environments depend for a healthy existence and comfort on abundance of food, oxygen, and a subdued light. Yet how many fish are kept in a glass bowl, the bowl placed in the bright light of a window, the water seldom if ever aerated, and the fish occasionally offered a little vermicelli. These fish are expected to be interesting. It would be as reasonable to keep an accepted wit in a dark, badly ventilated cellar of your house, feed him occasionally on a plate of worms, and expect him to bubble with good humour when visited by yourself and your friends.

I have referred to the photography of fish in natural environments and in tanks; with the latter method I would like to compare the photography of fish in the pond.

Photography in a glass tank is undoubtedly the best

ALARMED PERCH ADVANCING TOWARDS THE DARK CHAMBER IN THE POND.

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method of showing the shape and general outline of a fish, for by this means one can obtain whatever amount of contrast and clearness one may desire. But for all other forms of fish photography, the pond—or, failing the pond, a tank, which works on the same principle—is by far the most satisfactory, for the following reasons: the fish is illuminated as in nature, and as he does not see the photographer he is not disturbed. In the pond, as already stated, the conditions so nearly simulate the usual surroundings of most fish that they very soon are quite at home. From a photographer's point of view, photography in the dark chamber of the observation pond is child's play as compared with photography in a tank, for reflection is not a hampering factor, and the fish being at home swims leisurely about.

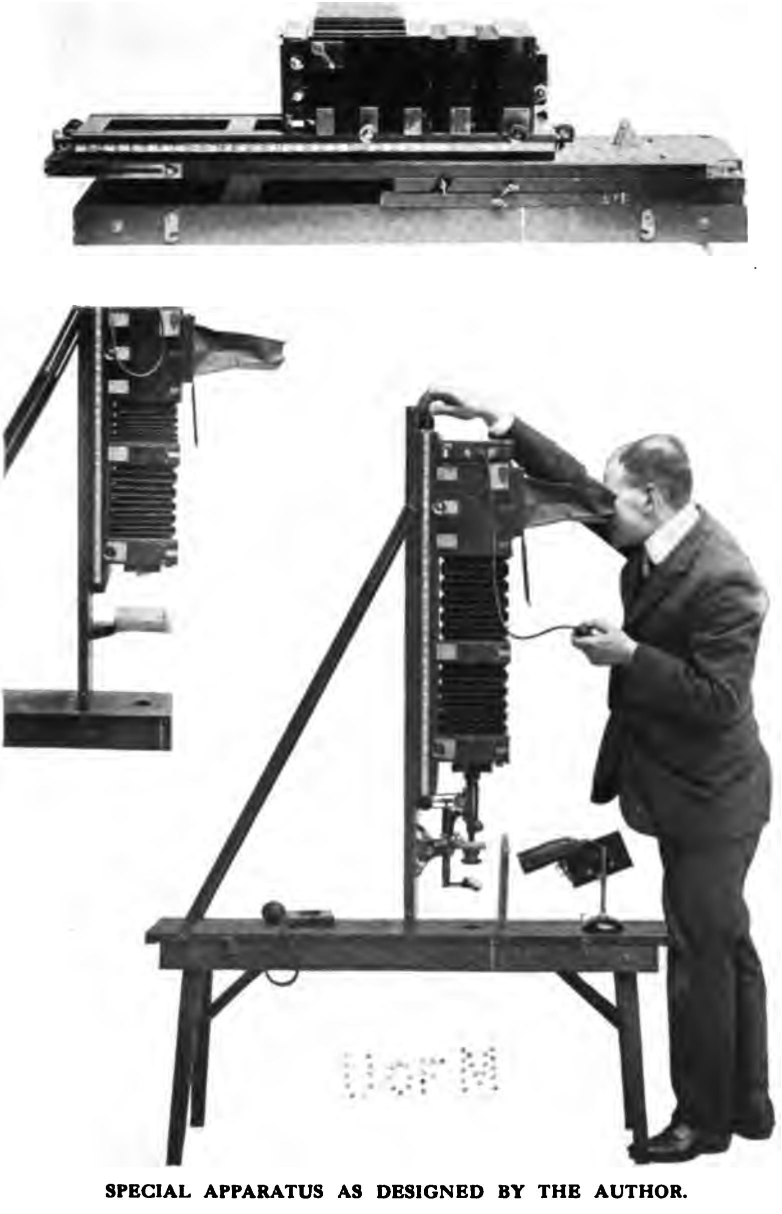
I have described how the attitudes of the perch on the plate facing p. 6 were only obtained after considerable trouble. In contrast with this I here show a photograph of a perch in an attitude of alarm swimming towards the dark chamber in the pond. This photograph was taken in the early morning, before breakfast; was the only negative exposed; and was obtained after watching for ten minutes. The cause of alarm was that the little perch had seized a worm before a large rainbow trout could get at it, and the rainbow had been chasing the perch.

Photographs of colour arrangements and markings on fish as concealing factors are valueless, except when taken with the fish illuminated as in nature, and I have already illustrated how these photographs can be obtained in the pond.

Now let us turn our attention to the camera, lenses, plates and exposures. For general use I would recommend a reflex camera, taking a five by four inch plate, with a lens of eight or nine inches focal length, and working at *f*4. The fastest backed autochromatic plates compatible with easy manipulation must be used. Several factors affect exposure in fish photography beyond those that have to be taken into account in ordinary photography. For example, some fish invariably move much faster than others; and, again, the water in which the fish is photographed varies considerably in clearness. As a general rule, I would recommend the photographer to decide what would be the correct exposure for any particular fish if placed in front of the tank. In fresh water 25 per cent. and in sea water 50 per cent. increased exposure should be allowed for every six inches of water through which the photograph is taken. Exposures in the pond vary according to the depth at which the fish is down in the water.

Now we come to the photography of smaller forms of fish life.

At Port Erin I took the photographs of the transformation of the plaice on the plates facing p. 114 with an improvised apparatus. Provided that the illumination is sufficiently good, and that the lenses are suitable for the work, it is possible to get quite as satisfactory a result with an improvised apparatus as with a more elaborate



SPECIAL APPARATUS AS DESIGNED BY THE AUTHOR.

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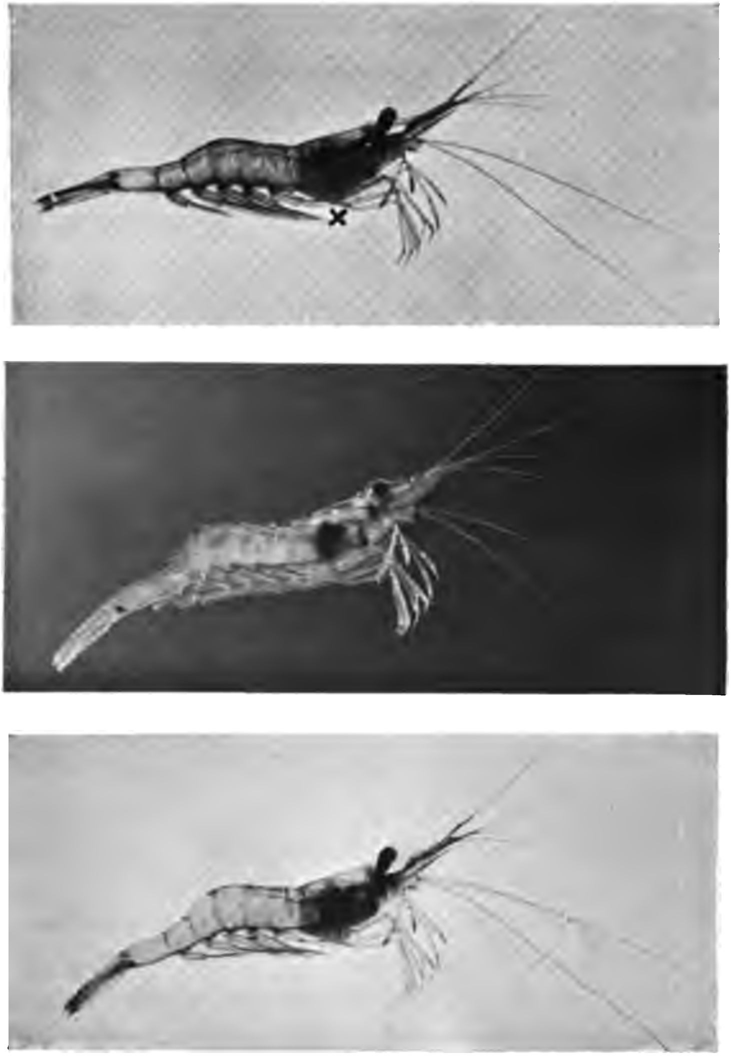
one. The difficulty, however, consists in the fact that with the less elaborate apparatus a great deal of dodging and manipulation is required, which necessitates assistance. In order to facilitate photography of larval fishes, on my return from Port Erin I constructed an apparatus by means of which it is possible single-handed to take a photograph of living objects in a vertical or horizontal position by daylight or by artificial illumination. Further, the object can be photographed life-size (provided it is not more than five inches in length), or any part of it up to a magnification of 2,700.

The aim I had in view when constructing this apparatus was that an expert biologist should be able to put an object in a certain position upon the stage, and that any ordinary photographer should be able to photograph it at any given magnification by transmitted or reflected light, night or day, without touching it.

I have illustrated the photographer at work with this apparatus in the horizontal position taking a photograph of a larval fish. The movements of the young fish in the live cell are watched on the mirror of this reflex micro-photographic camera. With the right hand the object is kept in sharp focus all the time by turning a screw which is connected with the microscope. As soon as the larval fish is in the desired position, an exposure is made by releasing the focal plane shutter with the bulb in the left hand.

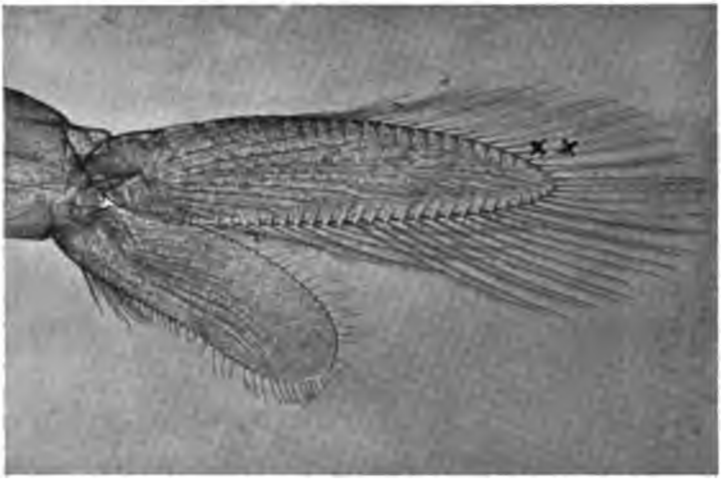
Working with an arc lamp of 1,200 candle-power, and with a cooling tank between the light and the object to be photographed, the usual exposure up to twenty-five magnifications on a slow plate is one-fifth of a second. Magnification above this requires one to three seconds. The photograph of oyster spat on the plate facing p. 148 shows a micro-photograph of the living moving oyster spat magnified sixty times, and taken at one-tenth of a second. When it is desired to take a photograph from life size up to ten magnifications, the microscope is slipped out, and a tank is fixed in place of the former, as illustrated. All the photographs, such as the embryo thornback ray, the hatching salmon, and the developing roach, were taken in this manner.

The reason for the great length of bellows is that it is possible to get considerable magnifications with lenses of comparatively long focal lengths; in this way objects that have considerable thickness are sharp in focus all over. It is not within the province of a book of this character to deal at length with the various ways of manipulating artificial light, or to describe the various modifications of live cells that I use, but I would briefly refer to a method I employ of obtaining a true rendering of transparency in marine larvæ and crustaceans. Take, for example, a small shrimp. If the light is merely transmitted through this crustacean into the lens, the result obtained in no way suggests the transparency of a shrimp. (*See* top photograph in the opposite plate.) The

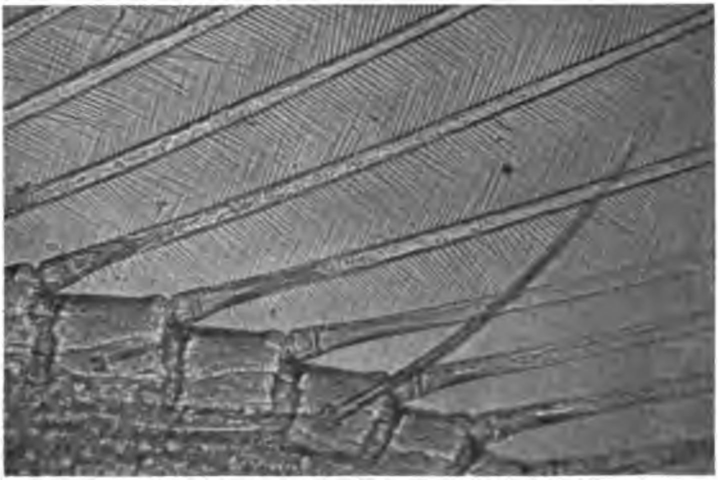


HOW TO SUGGEST TRANSPARENCY IN THE PHOTOGRAPHY OF MARINE ANIMALS.

(The portion marked × is shown enlarged on the next plate.)



LOW-POWER MICRO-PHOTOGRAPHY OF A PARTICULAR PART.
Taken without disturbing the animal.



HIGHER MAGNIFICATION OF POINT MARKED X X IN THE ABOVE ILLUSTRATION.

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light should be moved slightly to one side, so that it still falls on the shrimp, but not into the lens. A negative taken with the light in this position would give the result as shown in the second illustration on the same plate. Next, without moving the light, a sheet of ground glass should be placed between the light and the shrimp. The shrimp is now illuminated by a combined transmitted and reflected light, and the resulting photograph suggests transparency. As an illustration of how parts of this same shrimp can be photographed without its being moved, a higher power was now put on the camera, and a photograph taken of the part marked x, the result of which is shown in the top illustration on the next plate. The microscope can now be slipped into position and the part marked x x magnified up, as shown in the lower illustration on the same plate.

I have mentioned various tanks and apparatus, but in addition to these, not infrequently I have built a special tank in order to obtain a single photograph. But if asked what apparatus I would recommend to anyone starting fish photography, I would say, construct a tank on the principles of the pond.

On my next photographic holiday, I intend to take with me a wooden tank four feet square and two feet deep, with two opposite sides of plate glass. When it is desired to photograph a fish by a front light, I shall be able to use this box-like tank, as already described.

When it is desired to photograph a fish illuminated as in nature, I shall fix a rough canvas tent in front of one of the glass sides, which will take the place of the dark chamber in the pond, and I shall bank up the other glass side with rocks, reeds, or seaweed, and thus obtain photographs of fish with the illumination entirely from above, as in nature.

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